REGULATION OF HUMAN TRANSIENT RECEPTOR POTENTIAL CHANNEL

TECHNICAL FIELD OF THE INVENTION

The invention relates to the area of ion channel regulation.

BACKGROUND OF THE INVENTION

Ion channel

Because of the important biological effects of ion channel proteins, there is a need in the art to identify additional channels whose activity can be regulated to provide therapeutic effects.

Cold- and menthol-sensitive receptor and transient receptor potential channel

A cold- and menthol-sensitive receptor (CMR1) derived from rat has been cloned recently [McKemy D.D., Neuhausser W.M., and Julius, D.: Identification of a cold receptor reveals a general role for TRP channels in thermosensation. Nature 416:52-58, 2002]. This receptor is an excitatory ion channel expressed by small-diameter neurons in trigeminal and dorsal root ganglia. This channel receptor is activated by cold temperature (8-28°C) and menthol as a chemical agonist of a thermally responsive receptor, eliciting the same sensation of cool feeling. CMR1 belongs in a member of the transient receptor potential (TRP) channel subfamily, which is similar to other thermoreceptors, VR1 and VRL1, responding with a noxious heat and transfer the sensory information to the spinal cord and brain [Nagy I., Rang H.: Noxious heat activates all capsaicin-sensitive and also a sub-population of capsaicin-insensitive dorsal root ganglion neurons. Neuroscience 88:995-997, 1999] [Cesare

P., McNaughton P.: A novel heat-activated current in nociceptive neurons and its sensitization by bradykinin. Proc. Natl. Acad. Sci. U.S.A. 93:15435-15439, 1996].

Recently cloned human Trp-p8 (highly homologous to mouse TRPM8) is selectively expressed in prostate whereas its physiological function has not been revealed [Tsavaler L., Shapero M.H., Morkowski S., Laus R.: Trp-p8, a novel prostate-specific gene, is up-regulated in prostate cancer and other malignancies and shares high homology with transient receptor potential calcium channel proteins. Cancer Res. 61:3760-3769, 2001]. The function of mouse TRPM8 was characterized as an ion channel gated by cold stimuli and menthol, and its expression was limited in a subpopulation of the pain- and temperature-sensing DRG neurons [Peier A.M., Moqrich A., Hergarden A.C., Reeve A.J., Andersson D.A., Story G.M., Earley T.J., Dragoni I., McIntyre P., Bevan S., Patapoutian A.: A TRP Channel that Senses Cold Stimuli and Menthol. Cell 108:705-715, 2002]. The properties of the ion channel appear to be very similar to those of a cold- and menthol- activated current described in a patch-clamp analysis of dissociated DRG neurons [Reid G. and Flonta M.L.: Cold current in thermoreceptive neurons. Nature 413:480, 2001].

Human Trp-p8 is 92% and 93% identical to rat CMR1 and mouse TRPM8, respectively, suggesting that Trp-p8 is thus likely to be the human orthologue of rat CMR1 and mouse TRPM8. [Tsavaler L., Shapero M.H., Morkowski S., Laus R.: Trp-p8, a novel prostate-specific gene, is up-regulated in prostate cancer and other malignancies and shares high homology with transient receptor potential calcium channel proteins. Cancer Res. 61:3760-3769, 2001] [McKemy D.D., Neuhausser W.M., and Julius D.: Identification of a cold receptor reveals a general role for TRP channels in thermosensation. Nature 416:52-58, 2002] [Peier A.M., Moqrich A., Hergarden A.C., Reeve A.J., Andersson D.A., Story G.M., Earley T.J., Dragoni I., McIntyre P., Bevan S., Patapoutian A.: A TRP Channel that Senses Cold Stimuli and Menthol. Cell 108:705-715, 2002].

SUMMARY OF THE INVENTION

It is an object of the present invention to provide reagents and methods for regulating transient receptor potential channel. This and other objectives of the invention are provided by one of the embodiments described below.

One embodiment of the invention is a method of screening for agents which can regulate the activity of transient receptor potential channel, thus useful for treating the diseases associated with the activity. A test compound is contacted with a human polypeptide comprising an amino acid sequence which is at least about 70% identical to any one of the amino acid sequence shown in SEQ ID NOs: 12 to 21. Binding of the test compound to the polypeptide is detected. A test compound which binds to the polypeptide is thereby identified as a potential therapeutic agent for regulating the activity of transient receptor potential channel.

Another embodiment of the invention is a method of screening for agents which may be useful for treating diseases associated with the activity of transient receptor potential channel. The expression of a polynucleotide encoding a human transient receptor potential channel protein comprising the amino acid sequence of at least about 70% identical to any one of the amino acid sequence shown in SEQ ID NOS: 12 to 21 is assayed in the presence and absence of a test compound. A test compound that increases the expression is identified as a candidate therapeutic agent that may be useful for treating diseases associated with transient receptor potential channel. Alternatively, a test compound that decreases the expression is identified as a candidate therapeutic agent that may be useful for treating diseases associated with transient receptor potential channel. Another embodiment of the invention is a method of screening for agents which decrease the activity of transient receptor potential channel. A test compound is contacted with a polynucleotide encoding a transient receptor potential channel polypeptide, wherein the polynucleotide comprises a nucleotide sequence which are at least about 70% identical to any one of the nucleotide sequence shown in SEQ NO:1 to 11.

Another embodiment of the invention is a method of screening for agents which regulate a biological activity mediated by a transient receptor potential channel. A test compound is contacted with a polypeptide comprising an amino acid sequence which is at least about 70% identical to any one of the amino acid sequence shown in SEQ ID NO: 12 to 21. A biological activity mediated by the polypeptide is detected. A test compound which decreases the biological activity is thereby identified as a potential therapeutic agent for decreasing the biological activity of the transient receptor potential channel. A test compound which increases the biological activity is thereby identified as a potential therapeutic agent for increasing the biological activity of the human transient receptor potential channel.

Yet another embodiment of the invention is a method of screening for agents which regulate an activity of a human transient receptor potential channel. A test compound is contacted with a product encoded by a polynucleotide which comprises a nucleotide sequence which is at least 70% identical to any one of the nucleotide sequence shown in SEQ ID NO: 1 to 11. Binding of the test compound to the product is detected. A test compound which binds to the product is thereby identified as a potential therapeutic agent for regulating the activity of the human transient receptor potential channel. Even another embodiment of the invention is a method for treating a disease associated with transient receptor potential channel. The method comprises the step of administering to a patient with a disease associated with transient receptor potential channel an effective amount of a reagent that either (a) decreases expression of a human transient receptor potential channel gene that encodes a human transient receptor potential channel protein comprising the amino acid sequence at least 70% identical to any one of the sequence shown in SEQ ID NOs: 12 to 21 or (b) decreases effective level of the transient receptor potential channel protein, whereby symptoms of the diseases associated with transient receptor potential channel are reduced. Alternatively, the method comprises the step of administering to a patient with a disease associated with transient receptor potential channel an effective amount of an transient receptor potential channel agonist, a

protein or an expression vector, encoding a transient receptor potential channel protein, whereby symptoms of a disease associated with transient receptor potential channel are reduced.

Even another embodiment of the invention is a method of reducing activity of a human transient receptor potential channel. A cell is contacted with a reagent which specifically binds to a product encoded by a polynucleotide comprising a nucleotide sequence which is at least 70% identical to any one of the nucleotide sequence shown in SEQ ID NOs: 1 to 11. The activity of the human is transient receptor potential channel thereby reduced. Even another embodiment of the invention is a pharmaceutical composition comprising a reagent which specifically binds to a product encoded by a polynucleotide comprising a nucleotide sequence which is at least 70% identical to any one of the nucleotide sequence shown in SEQ ID NO: 1 to 11 and a pharmaceutically acceptable carrier.

Another embodiment of the invention is a pharmaceutical composition which comprises a reagent which binds to an expression product of a human transient receptor potential channel gene encoding an transient receptor potential channel protein. The protein comprises the amino acid sequence at least 70% identical to any one of the sequence shown in SEQ ID NOS: 12 to 21; and a pharmaceutically acceptable carrier. Alternatively, a pharmaceutical composition may comprise a human transient receptor potential channel protein comprising the amino acid sequence at least 70% identical to any one of the amino acid sequence shown in SEQ ID Nos: 12 to 21, and a pharmaceutically acceptable carrier.

Another embodiment of the invention is the use of a reagent which specifically binds to a product encoded by a polynucleotide comprising a nucleotide sequence which is at least about 70% identical to any one of the nucleotide sequence shown in SEQ ID NO: 1 to 11 in the preparation of a medicament for the treatment of diseases that are caused by aberrant activity of this enzyme and diseases whose symptoms can be

ameliorated by stimulating or inhibiting the activity of transient receptor potential channel.

As used herein "diseases associated with transient receptor potential channel" include, for example, overactivity of bladder, hyperflexia, and benign prostatic hyperplasia. Thus, the invention provides a human transient receptor potential channel, which can be regulated to provide therapeutic effects.

DETAILED DESCRIPTION OF THE INVENTION

It is a discovery of the present invention that human transient receptor potential channels can be regulated to control diseases that are caused by aberrant activity of this enzyme and diseases whose symptoms can be ameliorated by stimulating or inhibiting the activity of transient receptor potential channel. Human transient receptor potential channel can be used to screen for human transient receptor potential channel activators and inhibitors.

Human transient receptor potential channel is believed to be useful in therapeutic methods to treat disorders such as cancer, cardiovascular disorders, CNS disorders, and asthma or other allergic or inflammatory diseases. The present invention provide a link between human transient receptor potential channels and treatment of urological disorders using activators or inhibitors of human transient receptor potential channel protein. Transient receptor potential channel can be regulated to control diseases such as caused by overactivity of bladder, hyperflexia, and benign prostatic hyperplasia.

A cooling compound, menthol, has a selective potentiating action on cold receptors and shifts the temperature response curve of the bladder cooling reflex towards higher temperatures in animals [Lindstrom S. and Mazières L.: Acta Physiol Scand, 141: 1, 1991] [Mazières L., Jiang C. and Lindström S.: J Physiol (Lond), 513: 531, 1998]. Menthol treatment also causes a shift of the threshold temperature of the

cooling reflex towards a higher value in all tested patients [Geirsson G.: J. Urol. 150:427, 1993]. Electrophysiological studies indicated the existence of a cold sensitive receptor in dorsal root ganglion (DRG) neurons and suggested that menthol utilizes the same receptors which mediate the signals of cool temperature. The cold signal is possibly transduced through the direct opening of calcium-permeable ion channels [Reid G., Flonta M.L.: Nature 413:480, 2001]. Non-overactive bladder is defined as no involuntary detrusor contraction up to 400 ml of maximum fill on routine cystometry. In the ice water test (IWT) cystometry with ice water at 0 to 4°C at a rate of 100 ml per minute is performed. Clinically, for example, patients who show an involuntary detrusor contraction before 200, and between 200 and 400 ml of filling are considered positive. While ice water cystometry is considered negative when there is no involuntary detrusor contraction during ice water filling up to 400 ml. [Ismael S.S., Epstein T., Bayle B., Denys P., Amarenco G.: J. Urol. 164:1280-1284, 2000]. In the retrospective analysis of 557 patients with OAB, more than 90% of patients with upper motor neuron lesions were positive for IWT, but those with lower motor neural lesions were completely negative, confirming the usefulness of this test to discriminate these two types of OAB patients [Geirsson G.: J. Urol. 150:427,1993]. Interestingly, 75% of patients with CNS-related OAB, such as multiple sclerosis, Parkinson's disease or previous cerebrovascular accident, had positive results in IWT. In another study for 76 OAB patients with spinal disorders, 54% of patients were IWT-positive [Geirsson G., Fall M.: Scand. J. Urol. Nephrol. 29:457-461, 1995]. Furthermore, 12 out of 17 OAB patients with bladder outlet obstruction (71%) showed positive IWT [Chai T.C., Gray M.L., Steers W.D.: J. Urol. 160:34-38, 1998]. These evidences clearly demonstrate the appearance or functional up-regulation of the cold receptor-mediated reflex in more than half of OAB patients. Thus, human Trp-p8/CMR1 is a good target to modulate the OAB in the patients who respond to IWT.

Polypeptides

Human transient receptor potential channel polypeptides according to the invention comprise at least 6, 10, 15, 20, 25, 50, 75, 100, 125, 150, 175, 200, 225, 250, 275, 300, 400, 500, 600, 700, 800, 900, or 1000 contiguous amino acids selected from the amino acid sequence shown in SEQ ID NOs: 12 to 21 or a biologically active variant thereof, as defined below. A transient receptor potential channel polypeptide of the invention therefore can be a portion of a transient receptor potential channel protein, a full-length transient receptor potential channel protein, or a fusion protein comprising all or a portion of a transient receptor potential channel protein.

Biologically Active Variants

Human transient receptor potential channel polypeptide variants that are biologically active, *e.g.*, retain the ability to function as an ion channel, also are transient receptor potential channel polypeptides. Preferably, naturally or non-naturally occurring transient receptor potential channel polypeptide variants have amino acid sequences which are at least about 26, 30, 35, 40, 45, 50, 55, 60, 65, or 70, preferably about 75, 80, 85, 90, 96, 96, 98, or 99% identical to any one of the amino acid sequence shown in SEQ ID NOs: 12 to 21 or a fragment thereof. Percent identity between a putative transient receptor potential channel polypeptide variant and an amino acid sequence of SEQ ID NOs: 12 to 21 is determined by conventional methods. See, for example, Altschul et al., Bull. Math. Bio. 48:603 (1986), and Henikoff & Henikoff, Proc. Natl. Acad. Sci. USA 89:10915 (1992). Briefly, two amino acid sequences are aligned to optimize the alignment scores using a gap opening penalty of 10, a gap extension penalty of 1, and the "BLOSUM62" scoring matrix of Henikoff & Henikoff, 1992.

Those skilled in the art appreciate that there are many established algorithms available to align two amino acid sequences. The "FASTA" similarity search algorithm of Pearson & Lipman is a suitable protein alignment method for examining the

level of identity shared by an amino acid sequence disclosed herein and the amino acid sequence of a putative variant. The FASTA algorithm is described by Pearson & Lipman, Proc. Nat'l Acad. Sci. USA 85:2444(1988), and by Pearson, Meth. Enzymol. 183:63 (1990). Briefly, FASTA first characterizes sequence similarity by identifying regions shared by the query sequence (e.g., SEQ ID NO: 12 to 21) and a test sequence that have either the highest density of identities (if the ktup variable is 1) or pairs of identities (if ktup=2), without considering conservative amino acid substitutions, insertions, or deletions. The ten regions with the highest density of identities are then rescored by comparing the similarity of all paired amino acids using an amino acid substitution matrix, and the ends of the regions are "trimmed" to include only those residues that contribute to the highest score. If there are several regions with scores greater than the "cutoff" value (calculated by a predetermined formula based upon the length of the sequence the ktup value), then the trimmed initial regions are examined to determine whether the regions can be joined to form an approximate alignment with gaps. Finally, the highest scoring regions of the two amino acid sequences are aligned using a modification of the Needleman-Wunsch-Sellers algorithm (Needleman & Wunsch, J. Mol. Biol.48:444 (1970); Sellers, SIAM J. Appl. Math.26:787 (1974)), which allows for amino acid insertions and deletions. Preferred parameters for FASTA analysis are: ktup=1, gap opening penalty=10, gap extension penalty=1, and substitution matrix=BLOSUM62. These parameters can be introduced into a FASTA program by modifying the scoring matrix file ("SMATRIX"), as explained in Appendix 2 of Pearson, Meth. Enzymol. 183:63 (1990).

FASTA can also be used to determine the sequence identity of nucleic acid molecules using a ratio as disclosed above. For nucleotide sequence comparisons, the ktup value can range between one to six, preferably from three to six, most preferably three, with other parameters set as default.

Variations in percent identity can be due, for example, to amino acid substitutions, insertions, or deletions. Amino acid substitutions are defined as one for one amino

acid replacements. They are conservative in nature when the substituted amino acid has similar structural and/or chemical properties. Examples of conservative replacements are substitution of a leucine with an isoleucine or valine, an aspartate with a glutamate, or a threonine with a serine.

Amino acid insertions or deletions are changes to or within an amino acid sequence. They typically fall in the range of about 1 to 5 amino acids. Guidance in determining which amino acid residues can be substituted, inserted, or deleted without abolishing biological or immunological activity of a transient receptor potential channel polypeptide can be found using computer programs well known in the art, such as DNASTAR software. Whether an amino acid change results in a biologically active transient receptor potential channel polypeptide can readily be determined by assaying for functional activity, as described for example, in the "Functional Assays" section, below.

Fusion Proteins

Fusion proteins are useful for generating antibodies against transient receptor potential channel polypeptide amino acid sequences and for use in various assay systems. For example, fusion proteins can be used to identify proteins that interact with portions of a transient receptor potential channel polypeptide. Protein affinity chromatography or library-based assays for protein-protein interactions, such as the yeast two-hybrid or phage display systems, can be used for this purpose. Such methods are well known in the art and also can be used as drug screens.

A transient receptor potential channel polypeptide fusion protein comprises two polypeptide segments fused together by means of a peptide bond. The first polypeptide segment comprises at least 6, 10, 15, 20, 25, 50, 75, 100, 125, 150, 175, 200, 225, 250, 275, 300, 400, 500, 600, 700, 800, 900, or 1000 contiguous amino acids of any one of the sequences shown in SEQ ID NOs: 12 to 21 or of a

biologically active variant, such as those described above. The first polypeptide segment also can comprise full-length transient receptor potential channel protein.

The second polypeptide segment can be a full-length protein or a protein fragment. Proteins commonly used in fusion protein construction include β-galactosidase, β-glucuronidase, green fluorescent protein (GFP), autofluorescent proteins, including blue fluorescent protein (BFP), glutathione-S-transferase (GST), luciferase, horseradish peroxidase (HRP), and chloramphenicol acetyltransferase (CAT). Additionally, epitope tags are used in fusion protein constructions, including histidine (His) tags, FLAG tags, influenza hemagglutinin (HA) tags, Myc tags, VSV-G tags, and thioredoxin (Trx) tags. Other fusion constructions can include maltose binding protein (MBP), S-tag, Lex a DNA binding domain (DBD) fusions, GAL4 DNA binding domain fusions, and herpes simplex virus (HSV) BP16 protein fusions. A fusion protein also can be engineered to contain a cleavage site located between the transient receptor potential channel polypeptide-encoding sequence and the heterologous protein sequence, so that the transient receptor potential channel polypeptide can be cleaved and purified away from the heterologous moiety.

A fusion protein can be synthesized chemically, as is known in the art. Preferably, a fusion protein is produced by covalently linking two polypeptide segments or by standard procedures in the art of molecular biology. Recombinant DNA methods can be used to prepare fusion proteins, for example, by making a DNA construct which comprises coding sequences selected from SEQ ID NOs: 1 to 11 in proper reading frame with nucleotides encoding the second polypeptide segment and expressing the DNA construct in a host cell, as is known in the art. Many kits for constructing fusion proteins are available from companies such as Promega Corporation (Madison, WI), Stratagene (La Jolla, CA), CLONTECH (Mountain View, CA), Santa Cruz Biotechnology (Santa Cruz, CA), MBL International Corporation (MIC; Watertown, MA), and Quantum Biotechnologies (Montreal, Canada; 1-888-DNA-KITS).

Identification of Species Homologs

Species homologs of human transient receptor potential channel polypeptide can be obtained using transient receptor potential channel polypeptide polynucleotides (described below) to make suitable probes or primers for screening cDNA expression libraries from other species, such as mice, monkeys, or yeast, identifying cDNAs which encode homologs of transient receptor potential channel polypeptide, and expressing the cDNAs as is known in the art.

Polynucleotides

A transient receptor potential channel polynucleotide can be single- or double-stranded and comprises a coding sequence or the complement of a coding sequence for a transient receptor potential channel polypeptide. A coding sequence for human transient receptor potential channel is selected from the group consisting of SEQ ID NOs: 1 to 11.

Degenerate nucleotide sequences encoding human transient receptor potential channel polypeptides, as well as homologous nucleotide sequences which are at least about 50, 55, 60, 65, 70, preferably about 75, 90, 96, 98, or 99% identical to the nucleotide sequence shown in SEQ ID Nos 1 to 11 or its complement also are transient receptor potential channel polynucleotides. Percent sequence identity between the sequences of two polynucleotides is determined using computer programs such as ALIGN which employ the FASTA algorithm, using an affine gap search with a gap open penalty of -12 and a gap extension penalty of -2. Complementary DNA (cDNA) molecules, species homologs, and variants of transient receptor potential channel polynucleotides that encode biologically active transient receptor potential channel polypeptides also are transient receptor potential channel polynucleotides. Polynucleotide fragments comprising at least 8, 9, 10, 11, 12, 15, 20, or 25 contiguous nucleotides of any one of the sequences shown in SEQ ID Nos: 1 to 11 or its complement also are transient receptor potential channel

polynucleotides. These fragments can be used, for example, as hybridization probes or as antisense oligonucleotides.

Identification of Polynucleotide Variants and Homologs

Variants and homologs of the transient receptor potential channel polynucleotides described above also are transient receptor potential channel polynucleotides. Typically, homologous transient receptor potential channel polynucleotide sequences can be identified by hybridization of candidate polynucleotides to known transient receptor potential channel polynucleotides under stringent conditions, as is known in the art. For example, using the following wash conditions-2X SSC (0.3 M NaCl, 0.03 M sodium citrate, pH 7.0), 0.1% SDS, room temperature twice, 30 minutes each; then 2X SSC, 0.1% SDS, 50°C once, 30 minutes; then 2X SSC, room temperature twice, 10 minutes each-homologous sequences can be identified which contain at most about 25-30% basepair mismatches. More preferably, homologous nucleic acid strands contain 15-25% basepair mismatches, even more preferably 5-15% basepair mismatches.

Species homologs of the transient receptor potential channel polynucleotides disclosed herein also can be identified by making suitable probes or primers and screening cDNA expression libraries from other species, such as mice, monkeys, or yeast. Human variants of transient receptor potential channel polynucleotides can be identified, for example, by screening human cDNA expression libraries. It is well known that the T_m of a double-stranded DNA decreases by 1-1.5°C with every 1% decrease in homology (Bonner *et al.*, *J. Mol. Biol. 81*, 123 (1973). Variants of human transient receptor potential channel polynucleotides or transient receptor potential channel polynucleotides of other species can therefore be identified by hybridizing a putative homologous transient receptor potential channel polynucleotide with a polynucleotide having a any one of the nucleotide sequences of SEQ ID Nos 1 to 11 or the complement thereof to form a test hybrid. The melting temperature of the test hybrid is compared with the melting temperature of a hybrid

comprising polynucleotides having perfectly complementary nucleotide sequences, and the number or percent of basepair mismatches within the test hybrid is calculated.

Nucleotide sequences which hybridize to transient receptor potential channel polynucleotides or their complements following stringent hybridization and/or wash conditions also are transient receptor potential channel polynucleotides. Stringent wash conditions are well known and understood in the art and are disclosed, for example, in Sambrook *et al.*, MOLECULAR CLONING: A LABORATORY MANUAL, 2d ed., 1989, at pages 9.50-9.51.

Typically, for stringent hybridization conditions a combination of temperature and salt concentration should be chosen that is approximately 12-20°C below the calculated T_m of the hybrid under study. The T_m of a hybrid between a transient receptor potential channel polynucleotide having one nucleotide sequence selected from the group consisting of SEQ ID Nos : 1 to 11 or the complement thereof and a polynucleotide sequence which is at least about 50, preferably about 75, 90, 96, or 98% identical to one of those nucleotide sequences can be calculated, for example, using the equation of Bolton and McCarthy, *Proc. Natl. Acad. Sci. U.S.A. 48*, 1390 (1962):

$T_m = 81.5°C - 16.6(\log_{10}[Na^+]) + 0.41(\%G + C) - 0.63(\%\text{formamide}) - 600/l)$,
where l = the length of the hybrid in basepairs.

Stringent wash conditions include, for example, 4X SSC at 65°C, or 50% formamide, 4X SSC at 42°C, or 0.5X SSC, 0.1% SDS at 65°C. Highly stringent wash conditions include, for example, 0.2X SSC at 65°C.

Preparation of Polynucleotides

A transient receptor potential channel polynucleotide can be isolated free of other cellular components such as membrane components, proteins, and lipids. Polynucleotides can be made by a cell and isolated using standard nucleic acid purification techniques, or synthesized using an amplification technique, such as the polymerase chain reaction (PCR), or by using an automatic synthesizer. Methods for isolating polynucleotides are routine and are known in the art. Any such technique for obtaining a polynucleotide can be used to obtain isolated transient receptor potential channel polynucleotides. For example, restriction enzymes and probes can be used to isolate polynucleotide fragments, which comprise transient receptor potential channel nucleotide sequences. Isolated polynucleotides are in preparations that are free or at least 70, 80, or 90% free of other molecules.

Human transient receptor potential channel cDNA molecules can be made with standard molecular biology techniques, using transient receptor potential channel mRNA as a template. Human transient receptor potential channel cDNA molecules can thereafter be replicated using molecular biology techniques known in the art and disclosed in manuals such as Sambrook *et al.* (1989). An amplification technique, such as PCR, can be used to obtain additional copies of polynucleotides of the invention, using either human genomic DNA or cDNA as a template.

Alternatively, synthetic chemistry techniques can be used to synthesize transient receptor potential channel polynucleotides. The degeneracy of the genetic code allows alternate nucleotide sequences to be synthesized which will encode a transient receptor potential channel polypeptide having, for example, any one of the amino acid sequences shown in SEQ ID NOs: 12 to 21 or a biologically active variant thereof.

Extending Polynucleotides

The partial sequence disclosed herein can be used to identify the corresponding full length gene from which it was derived. The partial sequence can be nick-translated or end-labeled with ^{32}P using polynucleotide kinase using labeling methods known to those with skill in the art (BASIC METHODS IN MOLECULAR BIOLOGY, Davis *et al.*, eds., Elsevier Press, N.Y., 1986). A lambda library prepared from human tissue can be directly screened with the labeled sequences of interest or the library can be converted en masse to pBluescript (Stratagene Cloning Systems, La Jolla, Calif. 92037) to facilitate bacterial colony screening (see Sambrook *et al.*, MOLECULAR CLONING: A LABORATORY MANUAL, Cold Spring Harbor Laboratory Press (1989, pg. 1.20).

Both methods are well known in the art. Briefly, filters with bacterial colonies containing the library in pBluescript or bacterial lawns containing lambda plaques are denatured, and the DNA is fixed to the filters. The filters are hybridized with the labeled probe using hybridization conditions described by Davis *et al.*, 1986. The partial sequences, cloned into lambda or pBluescript, can be used as positive controls to assess background binding and to adjust the hybridization and washing stringencies necessary for accurate clone identification. The resulting autoradiograms are compared to duplicate plates of colonies or plaques; each exposed spot corresponds to a positive colony or plaque. The colonies or plaques are selected, expanded and the DNA is isolated from the colonies for further analysis and sequencing.

Positive cDNA clones are analyzed to determine the amount of additional sequence they contain using PCR with one primer from the partial sequence and the other primer from the vector. Clones with a larger vector-insert PCR product than the original partial sequence are analyzed by restriction digestion and DNA sequencing to determine whether they contain an insert of the same size or similar as the mRNA size determined from Northern blot Analysis.

Once one or more overlapping cDNA clones are identified, the complete sequence of the clones can be determined, for example after exonuclease III digestion (McCombie *et al.*, *Methods 3*, 33-40, 1991). A series of deletion clones are generated, each of which is sequenced. The resulting overlapping sequences are assembled into a single contiguous sequence of high redundancy (usually three to five overlapping sequences at each nucleotide position), resulting in a highly accurate final sequence.

Various PCR-based methods can be used to extend the nucleic acid sequences disclosed herein to detect upstream sequences such as promoters and regulatory elements. For example, restriction-site PCR uses universal primers to retrieve unknown sequence adjacent to a known locus (Sarkar, *PCR Methods Applic. 2*, 318-322, 1993). Genomic DNA is first amplified in the presence of a primer to a linker sequence and a primer specific to the known region. The amplified sequences are then subjected to a second round of PCR with the same linker primer and another specific primer internal to the first one. Products of each round of PCR are transcribed with an appropriate RNA polymerase and sequenced using reverse transcriptase.

Inverse PCR also can be used to amplify or extend sequences using divergent primers based on a known region (Triglia *et al.*, *Nucleic Acids Res. 16*, 8186, 1988). Primers can be designed using commercially available software, such as OLIGO 4.06 Primer Analysis software (National Biosciences Inc., Plymouth, Minn.), to be 22-30 nucleotides in length, to have a GC content of 50% or more, and to anneal to the target sequence at temperatures about 68-72 °C. The method uses several restriction enzymes to generate a suitable fragment in the known region of a gene. The fragment is then circularized by intramolecular ligation and used as a PCR template.

Another method which can be used is capture PCR, which involves PCR amplification of DNA fragments adjacent to a known sequence in human and yeast

artificial chromosome DNA (Lagerstrom *et al.*, *PCR Methods Applic. 1*, 111-119, 1991). In this method, multiple restriction enzyme digestions and ligations also can be used to place an engineered double-stranded sequence into an unknown fragment of the DNA molecule before performing PCR.

Another method which can be used to retrieve unknown sequences is that of Parker *et al.*, *Nucleic Acids Res. 19*, 3055-3060, 1991). Additionally, PCR, nested primers, and PROMOTERFINDER libraries (CLONTECH, Palo Alto, Calif.) can be used to walk genomic DNA (CLONTECH, Palo Alto, Calif.). This process avoids the need to screen libraries and is useful in finding intron/exon junctions.

When screening for full-length cDNAs, it is preferable to use libraries that have been size-selected to include larger cDNAs. Randomly-primed libraries are preferable, in that they will contain more sequences which contain the 5' regions of genes. Use of a randomly primed library may be especially preferable for situations in which an oligo d(T) library does not yield a full-length cDNA. Genomic libraries can be useful for extension of sequence into 5' non-transcribed regulatory regions.

Commercially available capillary electrophoresis systems can be used to analyze the size or confirm the nucleotide sequence of PCR or sequencing products. For example, capillary sequencing can employ flowable polymers for electrophoretic separation, four different fluorescent dyes (one for each nucleotide) that are laser activated, and detection of the emitted wavelengths by a charge coupled device camera. Output/light intensity can be converted to electrical signal using appropriate software (*e.g.* GENOTYPER and Sequence NAVIGATOR, Perkin Elmer), and the entire process from loading of samples to computer analysis and electronic data display can be computer controlled. Capillary electrophoresis is especially preferable for the sequencing of small pieces of DNA that might be present in limited amounts in a particular sample.

Obtaining Polypeptides

Human transient receptor potential channel polypeptides can be obtained, for example, by purification from human cells, by expression of transient receptor potential channel polynucleotides, or by direct chemical synthesis.

Protein Purification

Human transient receptor potential channel polypeptides can be purified from any cell that expresses the polypeptide, including host cells that have been transfected with transient receptor potential channel expression constructs. A purified transient receptor potential channel polypeptide is separated from other compounds that normally associate with the transient receptor potential channel polypeptide in the cell, such as certain proteins, carbohydrates, or lipids, using methods well-known in the art. Such methods include, but are not limited to, size exclusion chromatography, ammonium sulfate fractionation, ion exchange chromatography, affinity chromatography, and preparative gel electrophoresis. A preparation of purified transient receptor potential channel polypeptides is at least 80% pure; preferably, the preparations are 90%, 95%, or 99% pure. Purity of the preparations can be assessed by any means known in the art, such as SDS-polyacrylamide gel electrophoresis.

Expression of Polynucleotides

To express a transient receptor potential channel polynucleotide, the polynucleotide can be inserted into an expression vector that contains the necessary elements for the transcription and translation of the inserted coding sequence. Methods that are well known to those skilled in the art can be used to construct expression vectors containing sequences encoding transient receptor potential channel polypeptides and appropriate transcriptional and translational control elements. These methods include *in vitro* recombinant DNA techniques, synthetic techniques, and *in vivo* genetic recombination. Such techniques are described, for example, in Sambrook *et*

al. (1989) and in Ausubel *et al.*, CURRENT PROTOCOLS IN MOLECULAR BIOLOGY, John Wiley & Sons, New York, N.Y., 1989.

A variety of expression vector/host systems can be utilized to contain and express sequences encoding a transient receptor potential channel polypeptide. These include, but are not limited to, microorganisms, such as bacteria transformed with recombinant bacteriophage, plasmid, or cosmid DNA expression vectors; yeast transformed with yeast expression vectors, insect cell systems infected with virus expression vectors (*e.g.*, baculovirus), plant cell systems transformed with virus expression vectors (*e.g.*, cauliflower mosaic virus, CaMV; tobacco mosaic virus, TMV) or with bacterial expression vectors (*e.g.*, Ti or pBR322 plasmids), or animal cell systems.

The control elements or regulatory sequences are those non-translated regions of the vector -- enhancers, promoters, 5' and 3' untranslated regions -- which interact with host cellular proteins to carry out transcription and translation. Such elements can vary in their strength and specificity. Depending on the vector system and host utilized, any number of suitable transcription and translation elements, including constitutive and inducible promoters, can be used. For example, when cloning in bacterial systems, inducible promoters such as the hybrid lacZ promoter of the BLUESCRIPT phagemid (Stratagene, LaJolla, Calif.) or pSPORT1 plasmid (Life Technologies) and the like can be used. The baculovirus polyhedrin promoter can be used in insect cells. Promoters or enhancers derived from the genomes of plant cells (*e.g.*, heat shock, RUBISCO, and storage protein genes) or from plant viruses (*e.g.*, viral promoters or leader sequences) can be cloned into the vector. In mammalian cell systems, promoters from mammalian genes or from mammalian viruses are preferable. If it is necessary to generate a cell line that contains multiple copies of a nucleotide sequence encoding a transient receptor potential channel polypeptide, vectors based on SV40 or EBV can be used with an appropriate selectable marker.

Bacterial and Yeast Expression Systems

In bacterial systems, a number of expression vectors can be selected depending upon the use intended for the transient receptor potential channel polypeptide. For example, when a large quantity of a transient receptor potential channel polypeptide is needed for the induction of antibodies, vectors which direct high level expression of fusion proteins that are readily purified can be used. Such vectors include, but are not limited to, multifunctional *E. coli* cloning and expression vectors such as BLUESCRIPT (Stratagene). In a BLUESCRIPT vector, a sequence encoding the transient receptor potential channel polypeptide can be ligated into the vector in frame with sequences for the amino-terminal Met and the subsequent 7 residues of β-galactosidase so that a hybrid protein is produced. pIN vectors (Van Heeke & Schuster, *J. Biol. Chem. 264*, 5503-5509, 1989) or pGEX vectors (Promega, Madison, Wis.) also can be used to express foreign polypeptides as fusion proteins with glutathione S-transferase (GST). In general, such fusion proteins are soluble and can easily be purified from lysed cells by adsorption to glutathione-agarose beads followed by elution in the presence of free glutathione. Proteins made in such systems can be designed to include heparin, thrombin, or factor Xa protease cleavage sites so that the cloned polypeptide of interest can be released from the GST moiety at will.

In the yeast *Saccharomyces cerevisiae*, a number of vectors containing constitutive or inducible promoters such as alpha factor, alcohol oxidase, and PGH can be used. For reviews, see Ausubel *et al.* (1989) and Grant *et al.*, *Methods Enzymol. 153*, 516-544, 1987.

Plant and Insect Expression Systems

If plant expression vectors are used, the expression of sequences encoding transient receptor potential channel polypeptides can be driven by any of a number of promoters. For example, viral promoters such as the 35S and 19S promoters of

CaMV can be used alone or in combination with the omega leader sequence from TMV (Takamatsu, *EMBO J. 6*, 307-311, 1987). Alternatively, plant promoters such as the small subunit of RUBISCO or heat shock promoters can be used (Coruzzi *et al.*, *EMBO J. 3*, 1671-1680, 1984; Broglie *et al.*, *Science 224*, 838-843, 1984; Winter *et al.*, *Results Probl. Cell Differ. 17*, 85-105, 1991). These constructs can be introduced into plant cells by direct DNA transformation or by pathogen-mediated transfection. Such techniques are described in a number of generally available reviews (*e.g.*, Hobbs or Murray, in MCGRAW HILL YEARBOOK OF SCIENCE AND TECHNOLOGY, McGraw Hill, New York, N.Y., pp. 191-196, 1992).

An insect system also can be used to express a transient receptor potential channel polypeptide. For example, in one such system *Autographa californica* nuclear polyhedrosis virus (AcNPV) is used as a vector to express foreign genes in *Spodoptera frugiperda* cells or in *Trichoplusia* larvae. Sequences encoding transient receptor potential channel polypeptides can be cloned into a non-essential region of the virus, such as the polyhedrin gene, and placed under control of the polyhedrin promoter. Successful insertion of transient receptor potential channel polypeptides will render the polyhedrin gene inactive and produce recombinant virus lacking coat protein. The recombinant viruses can then be used to infect *S. frugiperda cells* or *Trichoplusia* larvae in which transient receptor potential channel polypeptides can be expressed (Engelhard *et al.*, *Proc. Nat. Acad. Sci. 91*, 3224-3227, 1994).

Mammalian Expression Systems

A number of viral-based expression systems can be used to express transient receptor potential channel polypeptides in mammalian host cells. For example, if an adenovirus is used as an expression vector, sequences encoding transient receptor potential channel polypeptides can be ligated into an adenovirus transcription/translation complex comprising the late promoter and tripartite leader sequence. Insertion in a non-essential E1 or E3 region of the viral genome can be used to obtain a viable virus that is capable of expressing a transient receptor potential channel polypeptide in

infected host cells (Logan & Shenk, *Proc. Natl. Acad. Sci. 81*, 3655-3659, 1984). If desired, transcription enhancers, such as the Rous sarcoma virus (RSV) enhancer, can be used to increase expression in mammalian host cells.

Human artificial chromosomes (HACs) also can be used to deliver larger fragments of DNA than can be contained and expressed in a plasmid. HACs of 6M to 10M are constructed and delivered to cells via conventional delivery methods (*e.g.*, liposomes, polycationic amino polymers, or vesicles).

Specific initiation signals also can be used to achieve more efficient translation of sequences encoding transient receptor potential channel polypeptides. Such signals include the ATG initiation codon and adjacent sequences. In cases where sequences encoding a transient receptor potential channel polypeptide, its initiation codon, and upstream sequences are inserted into the appropriate expression vector, no additional transcriptional or translational control signals may be needed. However, in cases where only coding sequence, or a fragment thereof, is inserted, exogenous translational control signals (including the ATG initiation codon) should be provided. The initiation codon should be in the correct reading frame to ensure translation of the entire insert. Exogenous translational elements and initiation codons can be of various origins, both natural and synthetic. The efficiency of expression can be enhanced by the inclusion of enhancers which are appropriate for the particular cell system which is used (see Scharf *et al.*, *Results Probl. Cell Differ. 20*, 125-162, 1994).

Host Cells

A host cell strain can be chosen for its ability to modulate the expression of the inserted sequences or to process the expressed transient receptor potential channel polypeptide in the desired fashion. Such modifications of the polypeptide include, but are not limited to, acetylation, carboxylation, glycosylation, phosphorylation, lipidation, and acylation. Post-translational processing which cleaves a "prepro"

form of the polypeptide also can be used to facilitate correct insertion, folding and/or function. Different host cells that have specific cellular machinery and characteristic mechanisms for post-translational activities (*e.g.*, CHO, HeLa, MDCK, HEK293, and WI38), are available from the American Type Culture Collection (ATCC; 10801 University Boulevard, Manassas, VA 20110-2209) and can be chosen to ensure the correct modification and processing of the foreign protein.

Stable expression is preferred for long-term, high-yield production of recombinant proteins. For example, cell lines which stably express transient receptor potential channel polypeptides can be transformed using expression vectors which can contain viral origins of replication and/or endogenous expression elements and a selectable marker gene on the same or on a separate vector. Following the introduction of the vector, cells can be allowed to grow for 1-2 days in an enriched medium before they are switched to a selective medium. The purpose of the selectable marker is to confer resistance to selection, and its presence allows growth and recovery of cells which successfully express the introduced transient receptor potential channel sequences. Resistant clones of stably transformed cells can be proliferated using tissue culture techniques appropriate to the cell type. See, for example, ANIMAL CELL CULTURE, R.I. Freshney, ed., 1986.

Any number of selection systems can be used to recover transformed cell lines.

These include, but are not limited to, the herpes simplex virus thymidine kinase (Wigler *et al.*, *Cell 11*, 223-32, 1977) and adenine phosphoribosyltransferase (Lowy *et al.*, *Cell 22*, 817-23, 1980) genes which can be employed in *tk*⁻ or *aprt*⁻ cells, respectively. Also, antimetabolite, antibiotic, or herbicide resistance can be used as the basis for selection. For example, *dhfr* confers resistance to methotrexate (Wigler *et al.*, *Proc. Natl. Acad. Sci. 77*, 3567-70, 1980), *npt* confers resistance to the aminoglycosides, neomycin and G-418 (Colbere-Garapin *et al.*, *J. Mol. Biol. 150*, 1-14, 1981), and *als* and *pat* confer resistance to chlorsulfuron and phosphinotricin acetyltransferase, respectively (Murray, 1992, *supra*). Additional selectable genes

have been described. For example, *trpB* allows cells to utilize indole in place of tryptophan, or *hisD*, which allows cells to utilize histinol in place of histidine (Hartman & Mulligan, *Proc. Natl. Acad. Sci. 85*, 8047-51, 1988). Visible markers such as anthocyanins, β-glucuronidase and its substrate GUS, and luciferase and its substrate luciferin, can be used to identify transformants and to quantify the amount of transient or stable protein expression attributable to a specific vector system (Rhodes *et al.*, *Methods Mol. Biol. 55*, 121-131, 1995).

Detecting Expression

Although the presence of marker gene expression suggests that the transient receptor potential channel polynucleotide is also present, its presence and expression may need to be confirmed. For example, if a sequence encoding a transient receptor potential channel polypeptide is inserted within a marker gene sequence, transformed cells containing sequences that encode a transient receptor potential channel polypeptide can be identified by the absence of marker gene function. Alternatively, a marker gene can be placed in tandem with a sequence encoding a transient receptor potential channel polypeptide under the control of a single promoter. Expression of the marker gene in response to induction or selection usually indicates expression of the transient receptor potential channel polynucleotide.

Alternatively, host cells which contain a transient receptor potential channel polynucleotide and which express a transient receptor potential channel polypeptide can be identified by a variety of procedures known to those of skill in the art. These procedures include, but are not limited to, DNA-DNA or DNA-RNA hybridizations and protein bioassay or immunoassay techniques that include membrane, solution, or chip-based technologies for the detection and/or quantification of nucleic acid or protein. For example, the presence of a polynucleotide sequence encoding a transient receptor potential channel polypeptide can be detected by DNA-DNA or DNA-RNA hybridization or amplification using probes or fragments or fragments of polynucleotides encoding a transient receptor potential channel polypeptide. Nucleic acid

amplification-based assays involve the use of oligonucleotides selected from sequences encoding a transient receptor potential channel polypeptide to detect transformants that contain a transient receptor potential channel polynucleotide.

A variety of protocols for detecting and measuring the expression of a transient receptor potential channel polypeptide, using either polyclonal or monoclonal antibodies specific for the polypeptide, are known in the art. Examples include enzyme-linked immunosorbent assay (ELISA), radioimmunoassay (RIA), and fluorescence activated cell sorting (FACS). A two-site, monoclonal-based immunoassay using monoclonal antibodies reactive to two non-interfering epitopes on a transient receptor potential channel polypeptide can be used, or a competitive binding assay can be employed. These and other assays are described in Hampton *et al.*, SEROLOGICAL METHODS: A LABORATORY MANUAL, APS Press, St. Paul, Minn., 1990) and Maddox *et al.*, *J. Exp. Med. 158*, 1211-1216, 1983).

A wide variety of labels and conjugation techniques are known by those skilled in the art and can be used in various nucleic acid and amino acid assays. Means for producing labeled hybridization or PCR probes for detecting sequences related to polynucleotides encoding transient receptor potential channel polypeptides include oligolabeling, nick translation, end-labeling, or PCR amplification using a labeled nucleotide. Alternatively, sequences encoding a transient receptor potential channel polypeptide can be cloned into a vector for the production of an mRNA probe. Such vectors are known in the art, are commercially available, and can be used to synthesize RNA probes *in vitro* by addition of labeled nucleotides and an appropriate RNA polymerase such as T7, T3, or SP6. These procedures can be conducted using a variety of commercially available kits (Amersham Pharmacia Biotech, Promega, and US Biochemical). Suitable reporter molecules or labels which can be used for ease of detection include radionuclides, enzymes, and fluorescent, chemiluminescent, or chromogenic agents, as well as substrates, cofactors, inhibitors, magnetic particles, and the like.

Expression and Purification of Polypeptides

Host cells transformed with nucleotide sequences encoding a transient receptor potential channel polypeptide can be cultured under conditions suitable for the expression and recovery of the protein from cell culture. The polypeptide produced by a transformed cell can be secreted or contained intracellularly depending on the sequence and/or the vector used. As will be understood by those of skill in the art, expression vectors containing polynucleotides which encode transient receptor potential channel polypeptides can be designed to contain signal sequences which direct secretion of soluble transient receptor potential channel polypeptides through a prokaryotic or eukaryotic cell membrane or which direct the membrane insertion of membrane-bound transient receptor potential channel polypeptide.

As discussed above, other constructions can be used to join a sequence encoding a transient receptor potential channel polypeptide to a nucleotide sequence encoding a polypeptide domain which will facilitate purification of soluble proteins. Such purification facilitating domains include, but are not limited to, metal chelating peptides such as histidine-tryptophan modules that allow purification on immobilized metals, protein A domains that allow purification on immobilized immunoglobulin, and the domain utilized in the FLAGS extension/affinity purification system (Immunex Corp., Seattle, Wash.). Inclusion of cleavable linker sequences such as those specific for Factor Xa or enterokinase (Invitrogen, San Diego, CA) between the purification domain and the transient receptor potential channel polypeptide also can be used to facilitate purification. One such expression vector provides for expression of a fusion protein containing a transient receptor potential channel polypeptide and 6 histidine residues preceding a thioredoxin or an enterokinase cleavage site. The histidine residues facilitate purification by IMAC (immobilized metal ion affinity chromatography, as described in Porath *et al.*, *Prot. Exp. Purif.* *3*, 263-281, 1992), while the enterokinase cleavage site provides a means for purifying the transient receptor potential channel polypeptide from the fusion protein. Vectors that contain fusion proteins are disclosed in Kroll *et al.*, *DNA Cell Biol.* *12*, 441-453, 1993.

Chemical Synthesis

Sequences encoding a transient receptor potential channel polypeptide can be synthesized, in whole or in part, using chemical methods well known in the art (see Caruthers *et al.*, *Nucl. Acids Res. Symp. Ser.* 215-223, 1980; Horn *et al. Nucl. Acids Res. Symp. Ser.* 225-232, 1980). Alternatively, a transient receptor potential channel polypeptide itself can be produced using chemical methods to synthesize its amino acid sequence, such as by direct peptide synthesis using solid-phase techniques (Merrifield, *J. Am. Chem. Soc. 85*, 2149-2154, 1963; Roberge *et al.*, *Science 269*, 202-204, 1995). Protein synthesis can be performed using manual techniques or by automation. Automated synthesis can be achieved, for example, using Applied Biosystems 431A Peptide Synthesizer (Perkin Elmer). Optionally, fragments of transient receptor potential channel polypeptides can be separately synthesized and combined using chemical methods to produce a full-length molecule.

The newly synthesized peptide can be substantially purified by preparative high performance liquid chromatography (*e.g.*, Creighton, PROTEINS: STRUCTURES AND MOLECULAR PRINCIPLES, WH Freeman and Co., New York, N.Y., 1983). The composition of a synthetic transient receptor potential channel polypeptide can be confirmed by amino acid analysis or sequencing (*e.g.*, the Edman degradation procedure; *see* Creighton, *supra*). Additionally, any portion of the amino acid sequence of the transient receptor potential channel polypeptide can be altered during direct synthesis and/or combined using chemical methods with sequences from other proteins to produce a variant polypeptide or a fusion protein.

Production of Altered Polypeptides

As will be understood by those of skill in the art, it may be advantageous to produce transient receptor potential channel polypeptide-encoding nucleotide sequences

possessing non-naturally occurring codons. For example, codons preferred by a particular prokaryotic or eukaryotic host can be selected to increase the rate of protein expression or to produce an RNA transcript having desirable properties, such as a half-life that is longer than that of a transcript generated from the naturally occurring sequence.

The nucleotide sequences disclosed herein can be engineered using methods generally known in the art to alter transient receptor potential channel polypeptide-encoding sequences for a variety of reasons, including but not limited to, alterations which modify the cloning, processing, and/or expression of the polypeptide or mRNA product. DNA shuffling by random fragmentation and PCR reassembly of gene fragments and synthetic oligonucleotides can be used to engineer the nucleotide sequences. For example, site-directed mutagenesis can be used to insert new restriction sites, alter glycosylation patterns, change codon preference, produce splice variants, introduce mutations, and so forth.

Antibodies

Any type of antibody known in the art can be generated to bind specifically to an epitope of a transient receptor potential channel polypeptide. "Antibody" as used herein includes intact immunoglobulin molecules, as well as fragments thereof, such as Fab, $F(ab')_2$, and Fv, which are capable of binding an epitope of a transient receptor potential channel polypeptide. Typically, at least 6, 8, 10, or 12 contiguous amino acids are required to form an epitope. However, epitopes which involve non-contiguous amino acids may require more, *e.g.*, at least 15, 25, or 50 amino acids.

An antibody which specifically binds to an epitope of a transient receptor potential channel polypeptide can be used therapeutically, as well as in immunochemical assays, such as Western blots, ELISAs, radioimmunoassays, immunohistochemical assays, immunoprecipitations, or other immunochemical assays known in the art. Various immunoassays can be used to identify antibodies having the desired

specificity. Numerous protocols for competitive binding or immunoradiometric assays are well known in the art. Such immunoassays typically involve the measurement of complex formation between an immunogen and an antibody that specifically binds to the immunogen.

Typically, an antibody which specifically binds to a transient receptor potential channel polypeptide provides a detection signal at least 5-, 10-, or 20-fold higher than a detection signal provided with other proteins when used in an immunochemical assay. Preferably, antibodies which specifically bind to transient receptor potential channel polypeptides do not detect other proteins in immunochemical assays and can immunoprecipitate a transient receptor potential channel polypeptide from solution.

Human transient receptor potential channel polypeptides can be used to immunize a mammal, such as a mouse, rat, rabbit, guinea pig, monkey, or human, to produce polyclonal antibodies. If desired, a transient receptor potential channel polypeptide can be conjugated to a carrier protein, such as bovine serum albumin, thyroglobulin, and keyhole limpet hemocyanin. Depending on the host species, various adjuvants can be used to increase the immunological response. Such adjuvants include, but are not limited to, Freund's adjuvant, mineral gels (*e.g.*, aluminum hydroxide), and surface active substances (*e.g.* lysolecithin, pluronic polyols, polyanions, peptides, oil emulsions, keyhole limpet hemocyanin, and dinitrophenol). Among adjuvants used in humans, BCG (*bacilli Calmette-Guerin*) and *Corynebacterium parvum* are especially useful.

Monoclonal antibodies that specifically bind to a transient receptor potential channel polypeptide can be prepared using any technique which provides for the production of antibody molecules by continuous cell lines in culture. These techniques include, but are not limited to, the hybridoma technique, the human B-cell hybridoma technique, and the EBV-hybridoma technique (Kohler *et al.*, *Nature 256*, 495-497, 1985; Kozbor *et al.*, *J. Immunol. Methods 81*, 31-42, 1985; Cote *et al.*, *Proc. Natl. Acad. Sci. 80*, 2026-2030, 1983; Cole *et al.*, *Mol. Cell Biol. 62*, 109-120, 1984).

In addition, techniques developed for the production of "chimeric antibodies," the splicing of mouse antibody genes to human antibody genes to obtain a molecule with appropriate antigen specificity and biological activity, can be used (Morrison *et al.*, *Proc. Natl. Acad. Sci. 81*, 6851-6855, 1984; Neuberger *et al.*, *Nature 312*, 604-608, 1984; Takeda *et al.*, *Nature 314*, 452-454, 1985). Monoclonal and other antibodies also can be "humanized" to prevent a patient from mounting an immune response against the antibody when it is used therapeutically. Such antibodies may be sufficiently similar in sequence to human antibodies to be used directly in therapy or may require alteration of a few key residues. Sequence differences between rodent antibodies and human sequences can be minimized by replacing residues which differ from those in the human sequences by site directed mutagenesis of individual residues or by grating of entire complementarity determining regions. Alternatively, humanized antibodies can be produced using recombinant methods, as described in GB2188638B. Antibodies that specifically bind to a transient receptor potential channel polypeptide can contain antigen binding sites which are either partially or fully humanized, as disclosed in U.S. 5,565,332.

Alternatively, techniques described for the production of single chain antibodies can be adapted using methods known in the art to produce single chain antibodies that specifically bind to transient receptor potential channel polypeptides. Antibodies with related specificity, but of distinct idiotypic composition, can be generated by chain shuffling from random combinatorial immunoglobin libraries (Burton, *Proc. Natl. Acad. Sci. 88*, 11120-23, 1991).

Single-chain antibodies also can be constructed using a DNA amplification method, such as PCR, using hybridoma cDNA as a template (Thirion *et al.*, 1996, *Eur. J. Cancer Prev. 5*, 507-11). Single-chain antibodies can be mono- or bispecific, and can be bivalent or tetravalent. Construction of tetravalent, bispecific single-chain antibodies is taught, for example, in Coloma & Morrison, 1997, *Nat. Biotechnol.*

15, 159-63. Construction of bivalent, bispecific single-chain antibodies is taught in Mallender & Voss, 1994, *J. Biol. Chem. 269*, 199-206.

A nucleotide sequence encoding a single-chain antibody can be constructed using manual or automated nucleotide synthesis, cloned into an expression construct using standard recombinant DNA methods, and introduced into a cell to express the coding sequence, as described below. Alternatively, single-chain antibodies can be produced directly using, for example, filamentous phage technology (Verhaar *et al.*, 1995, *Int. J. Cancer 61*, 497-501; Nicholls *et al.*, 1993, *J. Immunol. Meth. 165*, 81-91).

Antibodies which specifically bind to transient receptor potential channel polypeptides also can be produced by inducing *in vivo* production in the lymphocyte population or by screening immunoglobulin libraries or panels of highly specific binding reagents as disclosed in the literature (Orlandi *et al.*, *Proc. Natl. Acad. Sci. 86*, 3833-3837, 1989; Winter *et al.*, *Nature 349*, 293-299, 1991).

Other types of antibodies can be constructed and used therapeutically in methods of the invention. For example, chimeric antibodies can be constructed as disclosed in WO 93/03151. Binding proteins which are derived from immunoglobulins and which are multivalent and multispecific, such as the "diabodies" described in WO 94/13804, also can be prepared.

Antibodies according to the invention can be purified by methods well known in the art. For example, antibodies can be affinity purified by passage over a column to which a transient receptor potential channel polypeptide is bound. The bound antibodies can then be eluted from the column using a buffer with a high salt concentration.

Antisense Oligonucleotides

Antisense oligonucleotides are nucleotide sequences that are complementary to a specific DNA or RNA sequence. Once introduced into a cell, the complementary nucleotides combine with natural sequences produced by the cell to form complexes and block either transcription or translation. Preferably, an antisense oligonucleotide is at least 11 nucleotides in length, but can be at least 12, 15, 20, 25, 30, 35, 40, 45, or 50 or more nucleotides long. Longer sequences also can be used. Antisense oligonucleotide molecules can be provided in a DNA construct and introduced into a cell as described above to decrease the level of transient receptor potential channel gene products in the cell.

Antisense oligonucleotides can be deoxyribonucleotides, ribonucleotides, or a combination of both. Oligonucleotides can be synthesized manually or by an automated synthesizer, by covalently linking the 5' end of one nucleotide with the 3' end of another nucleotide with non-phosphodiester internucleotide linkages such alkylphosphonates, phosphorothioates, phosphorodithioates, alkylphosphonothioates, alkylphosphonates, phosphoramidates, phosphate esters, carbamates, acetamidate, carboxymethyl esters, carbonates, and phosphate triesters. *See* Brown, *Meth. Mol. Biol. 20*, 1-8, 1994; Sonveaux, *Meth. Mol. Biol. 26*, 1-72, 1994; Uhlmann *et al.*, *Chem. Rev. 90*, 543-583, 1990.

Modifications of transient receptor potential channel gene expression can be obtained by designing antisense oligonucleotides that will form duplexes to the control, 5', or regulatory regions of the transient receptor potential channel gene. Oligonucleotides derived from the transcription initiation site, *e.g.*, between positions -10 and +10 from the start site, are preferred. Similarly, inhibition can be achieved using "triple helix" base-pairing methodology. Triple helix pairing is useful because it causes inhibition of the ability of the double helix to open sufficiently for the binding of polymerases, transcription factors, or chaperons. Therapeutic advances using triplex DNA have been described in the literature (*e.g.*, Gee *et al.*, in Huber & Carr,

MOLECULAR AND IMMUNOLOGIC APPROACHES, Futura Publishing Co., Mt. Kisco, N.Y., 1994). An antisense oligonucleotide also can be designed to block translation of mRNA by preventing the transcript from binding to ribosomes.

Precise complementarity is not required for successful complex formation between an antisense oligonucleotide and the complementary sequence of a transient receptor potential channel polynucleotide. Antisense oligonucleotides which comprise, for example, 2, 3, 4, or 5 or more stretches of contiguous nucleotides which are precisely complementary to a transient receptor potential channel polynucleotide, each separated by a stretch of contiguous nucleotides which are not complementary to adjacent transient receptor potential channel nucleotides, can provide sufficient targeting specificity for transient receptor potential channel mRNA. Preferably, each stretch of complementary contiguous nucleotides is at least 4, 5, 6, 7, or 8 or more nucleotides in length. Non-complementary intervening sequences are preferably 1, 2, 3, or 4 nucleotides in length. One skilled in the art can easily use the calculated melting point of an antisense-sense pair to determine the degree of mismatching which will be tolerated between a particular antisense oligonucleotide and a particular transient receptor potential channel polynucleotide sequence.

Antisense oligonucleotides can be modified without affecting their ability to hybridize to a transient receptor potential channel polynucleotide. These modifications can be internal or at one or both ends of the antisense molecule. For example, internucleoside phosphate linkages can be modified by adding cholesteryl or diamine moieties with varying numbers of carbon residues between the amino groups and terminal ribose. Modified bases and/or sugars, such as arabinose instead of ribose, or a 3', 5'-substituted oligonucleotide in which the 3' hydroxyl group or the 5' phosphate group are substituted, also can be employed in a modified antisense oligonucleotide. These modified oligonucleotides can be prepared by methods well known in the art. *See, e.g.*, Agrawal *et al.*, *Trends Biotechnol. 10*, 152-158, 1992; Uhlmann *et al.*, *Chem. Rev. 90*, 543-584, 1990; Uhlmann *et al.*, *Tetrahedron. Lett. 215*, 3539-3542, 1987.

Ribozymes

Ribozymes are RNA molecules with catalytic activity. *See, e.g.*, Cech, *Science 236*, 1532-1539; 1987; Cech, *Ann. Rev. Biochem. 59*, 543-568; 1990, Cech, *Curr. Opin. Struct. Biol. 2*, 605-609; 1992, Couture & Stinchcomb, *Trends Genet. 12*, 510-515, 1996. Ribozymes can be used to inhibit gene function by cleaving an RNA sequence, as is known in the art (*e.g.*, Haseloff *et al.*, U.S. Patent 5,641,673). The mechanism of ribozyme action involves sequence-specific hybridization of the ribozyme molecule to complementary target RNA, followed by endonucleolytic cleavage. Examples include engineered hammerhead motif ribozyme molecules that can specifically and efficiently catalyze endonucleolytic cleavage of specific nucleotide sequences.

The coding sequence of a transient receptor potential channel polynucleotide can be used to generate ribozymes that will specifically bind to mRNA transcribed from the transient receptor potential channel polynucleotide. Methods of designing and constructing ribozymes which can cleave other RNA molecules in trans in a highly sequence specific manner have been developed and described in the art (*see* Haseloff *et al. Nature 334*, 585-591, 1988). For example, the cleavage activity of ribozymes can be targeted to specific RNAs by engineering a discrete "hybridization" region into the ribozyme. The hybridization region contains a sequence complementary to the target RNA and thus specifically hybridizes with the target (see, for example, Gerlach *et al.*, EP 321,201).

Specific ribozyme cleavage sites within a transient receptor potential channel RNA target can be identified by scanning the target molecule for ribozyme cleavage sites which include the following sequences: GUA, GUU, and GUC. Once identified, short RNA sequences of between 15 and 20 ribonucleotides corresponding to the region of the target RNA containing the cleavage site can be evaluated for secondary structural features which may render the target inoperable. Suitability of candidate

transient receptor potential channel RNA targets also can be evaluated by testing accessibility to hybridization with complementary oligonucleotides using ribonuclease protection assays. Longer complementary sequences can be used to increase the affinity of the hybridization sequence for the target. The hybridizing and cleavage regions of the ribozyme can be integrally related such that upon hybridizing to the target RNA through the complementary regions, the catalytic region of the ribozyme can cleave the target.

Ribozymes can be introduced into cells as part of a DNA construct. Mechanical methods, such as microinjection, liposome-mediated transfection, electroporation, or calcium phosphate precipitation, can be used to introduce a ribozyme-containing DNA construct into cells in which it is desired to decrease transient receptor potential channel expression. Alternatively, if it is desired that the cells stably retain the DNA construct, the construct can be supplied on a plasmid and maintained as a separate element or integrated into the genome of the cells, as is known in the art. A ribozyme-encoding DNA construct can include transcriptional regulatory elements, such as a promoter element, an enhancer or UAS element, and a transcriptional terminator signal, for controlling transcription of ribozymes in the cells.

As taught in Haseloff *et al.*, U.S. Patent 5,641,673, ribozymes can be engineered so that ribozyme expression will occur in response to factors that induce expression of a target gene. Ribozymes also can be engineered to provide an additional level of regulation, so that destruction of mRNA occurs only when both a ribozyme and a target gene are induced in the cells.

Differentially Expressed Genes

Described herein are methods for the identification of genes whose products interact with human transient receptor potential channel. Such genes may represent genes that are differentially expressed in disorders including, but not limited to, overactivity of bladder, hyperflexia, benign prostatic hyperplasia, and CNS disorders.

Further, such genes may represent genes that are differentially regulated in response to manipulations relevant to the progression or treatment of such diseases. Additionally, such genes may have a temporally modulated expression, increased or decreased at different stages of tissue or organism development. A differentially expressed gene may also have its expression modulated under control versus experimental conditions. In addition, the human transient receptor potential channel gene or gene product may itself be tested for differential expression.

The degree to which expression differs in a normal versus a diseased state need only be large enough to be visualized via standard characterization techniques such as differential display techniques. Other such standard characterization techniques by which expression differences may be visualized include but are not limited to, quantitative RT (reverse transcriptase), PCR, and Northern analysis.

Identification of Differentially Expressed Genes

To identify differentially expressed genes total RNA or, preferably, mRNA is isolated from tissues of interest. For example, RNA samples are obtained from tissues of experimental subjects and from corresponding tissues of control subjects. Any RNA isolation technique that does not select against the isolation of mRNA may be utilized for the purification of such RNA samples. See, for example, Ausubel *et al.*, ed., CURRENT PROTOCOLS IN MOLECULAR BIOLOGY, John Wiley & Sons, Inc. New York, 1987-1993. Large numbers of tissue samples may readily be processed using techniques well known to those of skill in the art, such as, for example, the single-step RNA isolation process of Chomczynski, U.S. Patent 4,843,155.

Transcripts within the collected RNA samples that represent RNA produced by differentially expressed genes are identified by methods well known to those of skill in the art. They include, for example, differential screening (Tedder *et al.*, *Proc. Natl. Acad. Sci. U.S.A. 85*, 208-12, 1988), subtractive hybridization (Hedrick *et al.*, *Nature 308*, 149-53; Lee *et al.*, *Proc. Natl. Acad. Sci. U.S.A. 88*, 2825, 1984), and,

preferably, differential display (Liang & Pardee, *Science 257*, 967-71, 1992; U.S. Patent 5,262,311).

The differential expression information may itself suggest relevant methods for the treatment of disorders involving the human transient receptor potential channel. For example, treatment may include a modulation of expression of the differentially expressed genes and/or the gene encoding the human transient receptor potential channel. The differential expression information may indicate whether the expression or activity of the differentially expressed gene or gene product or the human transient receptor potential channel gene or gene product are up-regulated or down-regulated.

Screening Methods

The invention provides assays for screening test compounds that bind to or modulate the activity of a transient receptor potential channel polypeptide or a transient receptor potential channel polynucleotide. A test compound preferably binds to a transient receptor potential channel polypeptide or polynucleotide. More preferably, a test compound decreases or increases functional activity by at least about 10, preferably about 50, more preferably about 75, 90, or 100% relative to the absence of the test compound.

Test Compounds

Test compounds can be pharmacologic agents already known in the art or can be compounds previously unknown to have any pharmacological activity. The compounds can be naturally occurring or designed in the laboratory. They can be isolated from microorganisms, animals, or plants, and can be produced recombinantly, or synthesized by chemical methods known in the art. If desired, test compounds can be obtained using any of the numerous combinatorial library methods known in the art, including but not limited to, biological libraries, spatially

to 500 µl. In addition to the plates, many instruments, materials, pipettors, robotics, plate washers, and plate readers are commercially available to fit the 96-well format.

Alternatively, "free format assays," or assays that have no physical barrier between samples, can be used. For example, an assay using pigment cells (melanocytes) in a simple homogeneous assay for combinatorial peptide libraries is described by Jayawickreme *et al.*, *Proc. Natl. Acad. Sci. U.S.A. 19,* 1614-18 (1994). The cells are placed under agarose in petri dishes, then beads that carry combinatorial compounds are placed on the surface of the agarose. The combinatorial compounds are partially released the compounds from the beads. Active compounds can be visualized as dark pigment areas because, as the compounds diffuse locally into the gel matrix, the active compounds cause the cells to change colors.

Another example of a free format assay is described by Chelsky, "Strategies for Screening Combinatorial Libraries: Novel and Traditional Approaches," reported at the First Annual Conference of The Society for Biomolecular Screening in Philadelphia, Pa. (Nov. 7-10, 1995). Chelsky placed a simple homogenous enzyme assay for carbonic anhydrase inside an agarose gel such that the enzyme in the gel would cause a color change throughout the gel. Thereafter, beads carrying combinatorial compounds via a photolinker were placed inside the gel and the compounds were partially released by UV-light. Compounds that inhibited the enzyme were observed as local zones of inhibition having less color change.

Another high throughput screening method is described in Beutel *et al.*, U.S. Patent 5,976,813. In this method, test samples are placed in a porous matrix. One or more assay components are then placed within, on top of, or at the bottom of a matrix such as a gel, a plastic sheet, a filter, or other form of easily manipulated solid support. When samples are introduced to the porous matrix they diffuse sufficiently slowly, such that the assays can be performed without the test samples running together.

addressable parallel solid phase or solution phase libraries, synthetic library methods requiring deconvolution, the "one-bead one-compound" library method, and synthetic library methods using affinity chromatography selection. The biological library approach is limited to polypeptide libraries, while the other four approaches are applicable to polypeptide, non-peptide oligomer, or small molecule libraries of compounds. *See* Lam, *Anticancer Drug Des. 12*, 145, 1997.

Methods for the synthesis of molecular libraries are well known in the art (*see*, for example, DeWitt *et al.*, *Proc. Natl. Acad. Sci. U.S.A. 90*, 6909, 1993; Erb *et al. Proc. Natl. Acad. Sci. U.S.A. 91*, 11422, 1994; Zuckermann *et al.*, *J. Med. Chem. 37*, 2678, 1994; Cho *et al.*, *Science 261*, 1303, 1993; Carell *et al.*, *Angew. Chem. Int. Ed. Engl. 33*, 2059, 1994; Carell *et al.*, *Angew. Chem. Int. Ed. Engl. 33*, 2061; Gallop *et al.*, *J. Med. Chem. 37*, 1233, 1994). Libraries of compounds can be presented in solution (*see*, *e.g.*, Houghten, *BioTechniques 13*, 412-421, 1992), or on beads (Lam, *Nature 354*, 82-84, 1991), chips (Fodor, *Nature 364*, 555-556, 1993), bacteria or spores (Ladner, U.S. Patent 5,223,409), plasmids (Cull *et al.*, *Proc. Natl. Acad. Sci. U.S.A. 89*, 1865-1869, 1992), or phage (Scott & Smith, *Science 249*, 386-390, 1990; Devlin, *Science 249*, 404-406, 1990); Cwirla *et al.*, *Proc. Natl. Acad. Sci. 97*, 6378-6382, 1990; Felici, *J. Mol. Biol. 222*, 301-310, 1991; and Ladner, U.S. Patent 5,223,409).

High Throughput Screening

Test compounds can be screened for the ability to bind to transient receptor potential channel polypeptides or polynucleotides or to affect transient receptor potential channel activity or transient receptor potential channel gene expression using high throughput screening. Using high throughput screening, many discrete compounds can be tested in parallel so that large numbers of test compounds can be quickly screened. The most widely established techniques utilize 96-well microtiter plates. The wells of the microtiter plates typically require assay volumes that range from 50

Binding Assays

For binding assays, the test compound is preferably a small molecule that binds to the transient receptor potential channel polypeptide such that normal biological activity is prevented. Examples of such small molecules include, but are not limited to, small peptides or peptide-like molecules.

In binding assays, either the test compound or the transient receptor potential channel polypeptide can comprise a detectable label, such as a fluorescent, radioisotopic, chemiluminescent, or enzymatic label, such as horseradish peroxidase, alkaline phosphatase, or luciferase. Detection of a test compound that is bound to the transient receptor potential channel polypeptide can then be accomplished, for example, by direct counting of radioemmission, by scintillation counting, or by determining conversion of an appropriate substrate to a detectable product.

Alternatively, binding of a test compound to a transient receptor potential channel polypeptide can be determined without labeling either of the interactants. For example, a microphysiometer can be used to detect binding of a test compound with a transient receptor potential channel polypeptide. A microphysiometer (*e.g.*, Cytosensor™) is an analytical instrument that measures the rate at which a cell acidifies its environment using a light-addressable potentiometric sensor (LAPS). Changes in this acidification rate can be used as an indicator of the interaction between a test compound and a transient receptor potential channel polypeptide (McConnell *et al.*, *Science 257*, 1906-1912, 1992).

Determining the ability of a test compound to bind to a transient receptor potential channel polypeptide also can be accomplished using a technology such as real-time Bimolecular Interaction Analysis (BIA) (Sjolander & Urbaniczky, *Anal. Chem. 63*, 2338-2345, 1991, and Szabo *et al.*, *Curr. Opin. Struct. Biol. 5*, 699-705, 1995). BIA is a technology for studying biospecific interactions in real time, without labeling any of the interactants (*e.g.*, BIAcore™). Changes in the optical

phenomenon surface plasmon resonance (SPR) can be used as an indication of real-time reactions between biological molecules.

In yet another aspect of the invention, a transient receptor potential channel polypeptide can be used as a "bait protein" in a two-hybrid assay or three-hybrid assay (see, *e.g.*, U.S. Patent 5,283,317; Zervos *et al.*, *Cell 72*, 223-232, 1993; Madura *et al.*, *J. Biol. Chem. 268*, 12046-12054, 1993; Bartel *et al.*, *BioTechniques 14*, 920-924, 1993; Iwabuchi *et al.*, *Oncogene 8*, 1693-1696, 1993; and Brent W094/10300), to identify other proteins which bind to or interact with the transient receptor potential channel polypeptide and modulate its activity.

The two-hybrid system is based on the modular nature of most transcription factors, which consist of separable DNA-binding and activation domains. Briefly, the assay utilizes two different DNA constructs. For example, in one construct, polynucleotide encoding a transient receptor potential channel polypeptide can be fused to a polynucleotide encoding the DNA binding domain of a known transcription factor (*e.g.*, GAL-4). In the other construct a DNA sequence that encodes an unidentified protein ("prey" or "sample") can be fused to a polynucleotide that codes for the activation domain of the known transcription factor. If the "bait" and the "prey" proteins are able to interact *in vivo* to form an protein-dependent complex, the DNA-binding and activation domains of the transcription factor are brought into close proximity. This proximity allows transcription of a reporter gene (*e.g.*, LacZ), which is operably linked to a transcriptional regulatory site responsive to the transcription factor. Expression of the reporter gene can be detected, and cell colonies containing the functional transcription factor can be isolated and used to obtain the DNA sequence encoding the protein that interacts with the transient receptor potential channel polypeptide.

It may be desirable to immobilize either the transient receptor potential channel polypeptide (or polynucleotide) or the test compound to facilitate separation of bound from unbound forms of one or both of the interactants, as well as to

accommodate automation of the assay. Thus, either the transient receptor potential channel polypeptide (or polynucleotide) or the test compound can be bound to a solid support. Suitable solid supports include, but are not limited to, glass or plastic slides, tissue culture plates, microtiter wells, tubes, silicon chips, or particles such as beads (including, but not limited to, latex, polystyrene, or glass beads). Any method known in the art can be used to attach the polypeptide (or polynucleotide) or test compound to a solid support, including use of covalent and non-covalent linkages, passive absorption, or pairs of binding moieties attached respectively to the polypeptide (or polynucleotide) or test compound and the solid support. Test compounds are preferably bound to the solid support in an array, so that the location of individual test compounds can be tracked. Binding of a test compound to a transient receptor potential channel polypeptide (or polynucleotide) can be accomplished in any vessel suitable for containing the reactants. Examples of such vessels include microtiter plates, test tubes, and microcentrifuge tubes.

In one embodiment, the transient receptor potential channel polypeptide is a fusion protein comprising a domain that allows the transient receptor potential channel polypeptide to be bound to a solid support. For example, glutathione-S-transferase fusion proteins can be adsorbed onto glutathione sepharose beads (Sigma Chemical, St. Louis, Mo.) or glutathione derivatized microtiter plates, which are then combined with the test compound or the test compound and the non-adsorbed transient receptor potential channel polypeptide; the mixture is then incubated under conditions conducive to complex formation (*e.g.*, at physiological conditions for salt and pH). Following incubation, the beads or microtiter plate wells are washed to remove any unbound components. Binding of the interactants can be determined either directly or indirectly, as described above. Alternatively, the complexes can be dissociated from the solid support before binding is determined.

Other techniques for immobilizing proteins or polynucleotides on a solid support also can be used in the screening assays of the invention. For example, either a transient receptor potential channel polypeptide (or polynucleotide) or a test compound can be

immobilized utilizing conjugation of biotin and streptavidin. Biotinylated transient receptor potential channel polypeptides (or polynucleotides) or test compounds can be prepared from biotin-NHS(N-hydroxysuccinimide) using techniques well known in the art (*e.g.*, biotinylation kit, Pierce Chemicals, Rockford, Ill.) and immobilized in the wells of streptavidin-coated 96 well plates (Pierce Chemical). Alternatively, antibodies which specifically bind to a transient receptor potential channel polypeptide, polynucleotide, or a test compound, but which do not interfere with a desired binding site can be derivatized to the wells of the plate. Unbound target or protein can be trapped in the wells by antibody conjugation.

Methods for detecting such complexes, in addition to those described above for the GST-immobilized complexes, include immunodetection of complexes using antibodies which specifically bind to the transient receptor potential channel polypeptide or test compound, enzyme-linked assays which rely on detecting an activity of the transient receptor potential channel polypeptide, and SDS gel electrophoresis under non-reducing conditions.

Screening for test compounds which bind to a transient receptor potential channel polypeptide or polynucleotide also can be carried out in an intact cell. Any cell which comprises a transient receptor potential channel polypeptide or polynucleotide can be used in a cell-based assay system. A transient receptor potential channel polynucleotide can be naturally occurring in the cell or can be introduced using techniques such as those described above. Binding of the test compound to a transient receptor potential channel polypeptide or polynucleotide is determined as described above.

Functional Assays

Test compounds can be tested for the ability to increase or decrease a biological effect of a human transient receptor potential channel. Such biological effects can be determined for example using functional assays such as those described below.

Functional assays can be carried out after contacting either a purified transient receptor potential channel polypeptide, a cell membrane preparation, or an intact cell with a test compound. A test compound which increases or decreases a functional activity of a transient receptor potential channel polypeptide by at least about 10, preferably about 50, more preferably about 75, 90, or 100% is identified as a potential therapeutic agent.

Ion channels can be tested functionally in living cells. Polypeptides comprising amino acid sequences encoded by open reading frames of the invention are either expressed endogeneously in appropriate reporter cells or are introduced recombinantly. Channel activity can be monitored by concentration changes of the permeating ion, by changes in the transmembrane electrical potential gradient, or by measuring a cellular response (*e.g.*, expression of a reporter gene or secretion of a neurotransmitter) triggered or modulated by the polypeptide's activity.

The activity of ion channel proteins in cells can be determined, for example, by loading the cells with an ion-sensitive fluorescent indicator. Fluorescent indicators can be loaded into cells in 96-well plates or another container, and the activity of ion channel proteins in the presence or absence of various test compounds can be simply and rapidly determined. *See, e.g.,* U.S. Patent 6,057,114. Ion channel currents result in changes of electrical membrane potential (V_m) which can be monitored directly using potentiometric fluorescent probes. These electrically charged indicators (*e.g.*, the anionic oxonol dye $DiBAC_4(3)$) redistribute between extra- and intracellular compartments in response to voltage changes across the membrane in which the ion channel resides. The equilibrium distribution is governed by the Nernst-equation. Thus, changes in membrane potential results in concomitant changes in cellular fluorescence. Again, changes in V_m might be caused directly by the activity of the target ion channel or through amplification and/or prolongation of the signal by channels co-expressed in the same cell.

Another approach to determining the activity of ion channel proteins involves the electrophysiological determination of ionic currents. Cells which endogenously express a transient receptor potential channel can be used to study the effects of various test compounds or transient receptor potential channel polypeptides on endogenous ionic currents attributable to the activity of transient receptor potential channels. Alternatively, cells which do not express transient receptor potential channel can be employed as hosts for the expression of transient receptor potential channel, whose activity can then be studied by electrophysiological or other means. Cells preferred as host cells for the heterologous expression of transient receptor potential channel are preferably mammalian cells such as COS cells, mouse L cells, CHO cells (e.g., DG44 cells), human embryonic kidney cells (e.g., HEK293 cells), African green monkey cells and the like; amphibian cells, such as *Xenopus laevis* oocytes; or cells of yeast such as *S. cerevisiae* or *P. pastoris*. *See, e.g.,* U.S. Patent 5,876,958.

Electrophysiological procedures for measuring the current across a cell membrane are well known. A preferred method is the use of a voltage clamp as in the whole-cell patch clamp technique. Non-calcium currents can be eliminated by established methods so as to isolate the ionic current flowing through ion channel proteins. In the case of heterologously expressed transient receptor potential channel, ionic currents resulting from endogenous ion channel proteins can be suppressed by known pharmacological or electrophysiological techniques. *See, e.g.,* U.S. Patent 5,876,958.

A further activity of the transient receptor potential channel which can be assessed is its ability to bind various ligands, including test compounds. The ability of a test compound to bind transient receptor potential channel or fragments thereof may be determined by any appropriate competitive binding analysis (*e.g.*, Scatchard plots), wherein the binding capacity and/or affinity is determined in the presence and absence of one or more concentrations a compound having known affinity for the transient receptor potential channel. Binding assays can be performed using whole

cells that express transient receptor potential channel (either endogenously or heterologously), membranes prepared from such cells, or purified transient receptor potential channel.

Gene Expression

In another embodiment, test compounds that increase or decrease transient receptor potential channel gene expression are identified. A transient receptor potential channel polynucleotide is contacted with a test compound, and the expression of an RNA or polypeptide product of the transient receptor potential channel polynucleotide is determined. The level of expression of appropriate mRNA or polypeptide in the presence of the test compound is compared to the level of expression of mRNA or polypeptide in the absence of the test compound. The test compound can then be identified as a modulator of expression based on this comparison. For example, when expression of mRNA or polypeptide is greater in the presence of the test compound than in its absence, the test compound is identified as a stimulator or enhancer of the mRNA or polypeptide expression. Alternatively, when expression of the mRNA or polypeptide is less in the presence of the test compound than in its absence, the test compound is identified as an inhibitor of the mRNA or polypeptide expression.

The level of transient receptor potential channel mRNA or polypeptide expression in the cells can be determined by methods well known in the art for detecting mRNA or polypeptide. Either qualitative or quantitative methods can be used. The presence of polypeptide products of a transient receptor potential channel polynucleotide can be determined, for example, using a variety of techniques known in the art, including immunochemical methods such as radioimmunoassay, Western blotting, and immunohistochemistry. Alternatively, polypeptide synthesis can be determined *in vivo*, in a cell culture, or in an *in vitro* translation system by detecting incorporation of labeled amino acids into a transient receptor potential channel polypeptide.

Such screening can be carried out either in a cell-free assay system or in an intact cell. Any cell that expresses a transient receptor potential channel polynucleotide can be used in a cell-based assay system. The transient receptor potential channel polynucleotide can be naturally occurring in the cell or can be introduced using techniques such as those described above. Either a primary culture or an established cell line, such as CHO or human embryonic kidney 293 cells, can be used.

Pharmaceutical Compositions

The invention also provides pharmaceutical compositions that can be administered to a patient to achieve a therapeutic effect. Pharmaceutical compositions of the invention can comprise, for example, a transient receptor potential channel polypeptide, transient receptor potential channel polynucleotide, ribozymes or antisense oligonucleotides, antibodies which specifically bind to a transient receptor potential channel polypeptide, or mimetics, activators, or inhibitors of a transient receptor potential channel polypeptide activity. The compositions can be administered alone or in combination with at least one other agent, such as stabilizing compound, which can be administered in any sterile, biocompatible pharmaceutical carrier, including, but not limited to, saline, buffered saline, dextrose, and water. The compositions can be administered to a patient alone, or in combination with other agents, drugs or hormones.

In addition to the active ingredients, these pharmaceutical compositions can contain suitable pharmaceutically-acceptable carriers comprising excipients and auxiliaries that facilitate processing of the active compounds into preparations which can be used pharmaceutically. Pharmaceutical compositions of the invention can be administered by any number of routes including, but not limited to, oral, intravenous, intramuscular, intra-arterial, intramedullary, intrathecal, intraventricular, transdermal, subcutaneous, intraperitoneal, intranasal, parenteral, topical, sublingual, or rectal means. Pharmaceutical compositions for oral administration can be formulated using pharmaceutically acceptable carriers well known in the art in dosages suitable for

oral administration. Such carriers enable the pharmaceutical compositions to be formulated as tablets, pills, dragees, capsules, liquids, gels, syrups, slurries, suspensions, and the like, for ingestion by the patient.

Pharmaceutical preparations for oral use can be obtained through combination of active compounds with solid excipient, optionally grinding a resulting mixture, and processing the mixture of granules, after adding suitable auxiliaries, if desired, to obtain tablets or dragee cores. Suitable excipients are carbohydrate or protein fillers, such as sugars, including lactose, sucrose, mannitol, or sorbitol; starch from corn, wheat, rice, potato, or other plants; cellulose, such as methyl cellulose, hydroxy-propylmethyl-cellulose, or sodium carboxymethylcellulose; gums including arabic and tragacanth; and proteins such as gelatin and collagen. If desired, disintegrating or solubilizing agents can be added, such as the cross-linked polyvinyl pyrrolidone, agar, alginic acid, or a salt thereof, such as sodium alginate.

Dragee cores can be used in conjunction with suitable coatings, such as concentrated sugar solutions, which also can contain gum arabic, talc, polyvinylpyrrolidone, carbopol gel, polyethylene glycol, and/or titanium dioxide, lacquer solutions, and suitable organic solvents or solvent mixtures. Dyestuffs or pigments can be added to the tablets or dragee coatings for product identification or to characterize the quantity of active compound, *i.e.*, dosage.

Pharmaceutical preparations that can be used orally include push-fit capsules made of gelatin, as well as soft, sealed capsules made of gelatin and a coating, such as glycerol or sorbitol. Push-fit capsules can contain active ingredients mixed with a filler or binders, such as lactose or starches, lubricants, such as talc or magnesium stearate, and, optionally, stabilizers. In soft capsules, the active compounds can be dissolved or suspended in suitable liquids, such as fatty oils, liquid, or liquid polyethylene glycol with or without stabilizers.

Pharmaceutical formulations suitable for parenteral administration can be formulated in aqueous solutions, preferably in physiologically compatible buffers such as Hanks' solution, Ringer's solution, or physiologically buffered saline. Aqueous injection suspensions can contain substances that increase the viscosity of the suspension, such as sodium carboxymethyl cellulose, sorbitol, or dextran. Additionally, suspensions of the active compounds can be prepared as appropriate oily injection suspensions. Suitable lipophilic solvents or vehicles include fatty oils such as sesame oil, or synthetic fatty acid esters, such as ethyl oleate or triglycerides, or liposomes. Non-lipid polycationic amino polymers also can be used for delivery. Optionally, the suspension also can contain suitable stabilizers or agents that increase the solubility of the compounds to allow for the preparation of highly concentrated solutions. For topical or nasal administration, penetrants appropriate to the particular barrier to be permeated are used in the formulation. Such penetrants are generally known in the art.

The pharmaceutical compositions of the present invention can be manufactured in a manner that is known in the art, *e.g.*, by means of conventional mixing, dissolving, granulating, dragee-making, levigating, emulsifying, encapsulating, entrapping, or lyophilizing processes. The pharmaceutical composition can be provided as a salt and can be formed with many acids, including but not limited to, hydrochloric, sulfuric, acetic, lactic, tartaric, malic, succinic, etc. Salts tend to be more soluble in aqueous or other protonic solvents than are the corresponding free base forms. In other cases, the preferred preparation can be a lyophilized powder which can contain any or all of the following: 1-50 mM histidine, 0.1%-2% sucrose, and 2-7% mannitol, at a pH range of 4.5 to 5.5, that is combined with buffer prior to use.

Further details on techniques for formulation and administration can be found in the latest edition of REMINGTON'S PHARMACEUTICAL SCIENCES (Maack Publishing Co., Easton, Pa.). After pharmaceutical compositions have been prepared, they can be placed in an appropriate container and labeled for treatment of an indicated

condition. Such labeling would include amount, frequency, and method of administration.

Therapeutic Indications and Methods

Modulating human transient receptor potential channel (TRPC) provides effective controls of urinary disorders such as urinary incontinence, overactive bladder, benign prostatic hyperplasia and lower urinary tract syndromes.

Urinary incontinence

Urinary incontinence (UI) is the involuntary loss of urine. Urge urinary incontinence (UUI) is one of the most common types of UI together with stress urinary incontinence, which is usually caused by a defect in the urethral closure mechanism. UUI is often associated with neurological disorders or diseases causing neuronal damage, such as dementia, Parkinson's disease, multiple sclerosis, stroke, and diabetes, although it also occurs in individuals with no such disorders. One of the usual causes of UUI is overactive bladder (OAB), which is a medical condition referring to the symptoms of frequency and urgency derived from abnormal contractions and instability of the detrusor muscle.

Rapid infusion of the bladder with ice water causes an immediate contraction of the detrusor in patients with spinal upper motor neuron lesions. The archaic cooling reflex is mediated through unmyelinated C afferent capsaicin sensitive fibers and normally inhibited by supraspinal centers. However, the cooling reflex is not inhibited in patients with upper motor neuron lesions. These involuntary detrusor contractions reflect spinal reflex signals originated by specific cold receptors in the bladder and urethral walls [Lindstrom S. and Mazières L.: Effect of menthol on the bladder cooling reflex in the cat. Acta Physiol Scand, 141: 1, 1991] [Mazières L., Jiang C. and Lindström S.: The C fibre reflex of the cat urinary bladder. J Physiol (Lond), 513: 531, 1998].

A cooling compound, menthol, has a selective potentiating action on cold receptors and shifts the temperature response curve of the bladder cooling reflex towards higher temperatures in animals [Lindstrom S. and Mazières L.: Effect of menthol on the bladder cooling reflex in the cat. Acta Physiol Scand, 141: 1, 1991] [Mazières L., Jiang C. and Lindström S.: The C fibre reflex of the cat urinary bladder. J Physiol (Lond), 513: 531, 1998]. Menthol treatment also causes a shift of the threshold temperature of the cooling reflex towards a higher value in all tested patients [Geirsson G.: Evidence of cold receptors in the human bladder: effect of menthol on the bladder cooling reflex. J. Urol. 150:427, 1993]. Electrophysiological studies indicated the existence of a cold sensitive receptor in dorsal root ganglion (DRG) neurons and suggested that menthol utilized the same receptors which mediate the signals of cool temperature. The cold signal was possibly transduced through the direct opening of calcium-permeable ion channels [Reid G., Flonta M.L.: Physiology. Cold current in thermoreceptive neurons. Nature 413:480, 2001].

Non-overactive bladder is defined as no involuntary detrusor contraction up to 400 ml of maximum fill on routine cystometry. In the ice water test (IWT) cystometry with ice water at 0 to 4°C at a rate of 100 ml per minute is performed. Clinically, for example, patients who show an involuntary detrusor contraction before 200, and between 200 and 400 ml of filling are considered positive. While ice water cystometry is considered negative when there is no involuntary detrusor contraction during ice water filling up to 400 ml. [Ismael S.S., Epstein T., Bayle B., Denys P., Amarenco G.: Bladder cooling reflex in patients with multiple sclerosis. J. Urol. 164:1280-1284, 2000]. In the retrospective analysis of 557 patients with OAB, more than 90% of patients with upper motor neuron lesions were positive for IWT, but those with lower motor neural lesions were completely negative, confirming the usefulness of this test to discriminate these two types of OAB patients [Geirsson G.: Evidence of cold receptors in the human bladder: effect of menthol on the bladder cooling reflex. J. Urol. 150:427,1993]. Interestingly, 75% of patients with CNS-related OAB, such as multiple sclerosis, Parkinson's disease or previous

cerebrovascular accident, had positive results in IWT. In another study for 76 OAB patients with spinal disorders, 54% of patients were IWT-positive [Geirsson G., Fall M.: Scand. J. Urol. Nephrol. 29:457-461, 1995]. Furthermore, 12 out of 17 OAB patients with bladder outlet obstruction (71%) showed positive IWT [Chai T.C., Gray M.L., Steers W.D.: The incidence of a positive ice water test in bladder outlet obstructed patients: evidence for bladder neural plasticity. J. Urol. 160:34-38, 1998]. These evidences clearly demonstrate the appearance or functional up-regulation of the cold receptor-mediated reflex in more than half of OAB patients. Thus, human Trp-p8/CMR1 is a good target to modulate the OAB in the patients who respond to IWT.

Benign Prostatic Hyperplasia

Benign prostatic hyperplasia (BPH) is the benign nodular hyperplasia of the periurethral prostate gland commonly seen in men over the age of 50. The overgrowth occurs in the central area of the prostate called the transition zone, which wraps around the urethra. BPH causes variable degrees of bladder outlet obstruction, which is one of the major symptoms of BPH. The actual cause of BPH is unknown but may involve age-related alterations in balance of steroidal sex hormones.

It was reported that Trp-p8 gene is most abundantly expressed in human prostate [Tsavaler L., Shapero M.H., Morkowski S., Laus R.: Trp-p8, a novel prostate-specific gene, is up-regulated in prostate cancer and other malignancies and shares high homology with transient receptor potential calcium channel proteins. Cancer Res. 61:3760-3769, 2001], suggesting an important role in the maintenance of the prostate cell growth through the regulation of intracellular Ca^{2+} concentration. Thus, drugs modulate Trp-p8 functional activity are useful to control either physical or functional control of the prostate.

Lower Urinary Tract Syndromes

BPH causes variable degrees of bladder outlet obstruction, resulting in progressive lower urinary tract syndromes (LUTS) characterized by urinary frequency, urgency, and nocturia due to incomplete emptying and rapid refilling of the bladder.

It was demonstrated that one of the major dysfunctions induced by partial outlet obstruction is a marked reduction in the participation of such calcium-induced calcium release during stimulation by both field stimulation and by direct muscarinic stimulation [Levin RM, et al. Scand. J. Urol. Suppl 184: 43-50, 1997]. Therefore, calcium storage and release play an important role in the contractile response of the rabbit urinary bladder to both neurotransmitter-mediated stimulation and direct smooth muscle stimulation. Thus, human transient receptor potential channel proteins can be good targets for controlling LUTS.

CNS disorders

Central and peripheral nervous system disorders also can be treated, such as primary and secondary disorders after brain injury, disorders of mood, anxiety disorders, disorders of thought and volition, disorders of sleep and wakefulness, diseases of the motor unit, such as neurogenic and myopathic disorders, neurodegenerative disorders such as Alzheimer's and Parkinson's disease, and processes of peripheral and chronic pain.

Pain that is associated with CNS disorders also can be treated by regulating the activity of human transient receptor potential channel. Pain which can be treated includes that associated with central nervous system disorders, such as multiple sclerosis, spinal cord injury, sciatica, failed back surgery syndrome, traumatic brain injury, epilepsy, Parkinson's disease, post-stroke, and vascular lesions in the brain and spinal cord (*e.g.*, infarct, hemorrhage, vascular malformation). Non-central neuropathic pain includes that associated with post mastectomy pain, reflex

sympathetic dystrophy (RSD), trigeminal neuralgiaradioculopathy, post-surgical pain, HIV/AIDS related pain, cancer pain, metabolic neuropathies (*e.g.*, diabetic neuropathy, vasculitic neuropathy secondary to connective tissue disease), paraneoplastic polyneuropathy associated, for example, with carcinoma of lung, or leukemia, or lymphoma, or carcinoma of prostate, colon or stomach, trigeminal neuralgia, cranial neuralgias, and post-herpetic neuralgia. Pain associated with cancer and cancer treatment also can be treated, as can headache pain (for example, migraine with aura, migraine without aura, and other migraine disorders), episodic and chronic tension-type headache, tension-type like headache, cluster headache, and chronic paroxysmal hemicrania.

This invention further pertains to the use of novel agents identified by the screening assays described above. Accordingly, it is within the scope of this invention to use a test compound identified as described herein in an appropriate animal model. For example, an agent identified as described herein (*e.g.*, a modulating agent, an antisense nucleic acid molecule, a specific antibody, ribozyme, or a transient receptor potential channel polypeptide binding molecule) can be used in an animal model to determine the efficacy, toxicity, or side effects of treatment with such an agent. Alternatively, an agent identified as described herein can be used in an animal model to determine the mechanism of action of such an agent. Furthermore, this invention pertains to uses of novel agents identified by the above-described screening assays for treatments as described herein.

A reagent which affects transient receptor potential channel activity can be administered to a human cell, either *in vitro* or *in vivo*, to reduce transient receptor potential channel activity. The reagent preferably binds to an expression product of a human transient receptor potential channel gene. If the expression product is a protein, the reagent is preferably an antibody. For treatment of human cells *ex vivo*, an antibody can be added to a preparation of stem cells that have been removed from the body. The cells can then be replaced in the same or another human body, with or without clonal propagation, as is known in the art.

In one embodiment, the reagent is delivered using a liposome. Preferably, the liposome is stable in the animal into which it has been administered for at least about 30 minutes, more preferably for at least about 1 hour, and even more preferably for at least about 24 hours. A liposome comprises a lipid composition that is capable of targeting a reagent, particularly a polynucleotide, to a particular site in an animal, such as a human. Preferably, the lipid composition of the liposome is capable of targeting to a specific organ of an animal, such as the lung, liver, spleen, heart brain, lymph nodes, and skin.

A liposome useful in the present invention comprises a lipid composition that is capable of fusing with the plasma membrane of the targeted cell to deliver its contents to the cell. Preferably, the transfection efficiency of a liposome is about 0.5 μg of DNA per 16 nmole of liposome delivered to about 10^6 cells, more preferably about 1.0 μg of DNA per 16 nmole of liposome delivered to about 10^6 cells, and even more preferably about 2.0 μg of DNA per 16 nmol of liposome delivered to about 10^6 cells. Preferably, a liposome is between about 100 and 500 nm, more preferably between about 150 and 450 nm, and even more preferably between about 200 and 400 nm in diameter.

Suitable liposomes for use in the present invention include those liposomes standardly used in, for example, gene delivery methods known to those of skill in the art. More preferred liposomes include liposomes having a polycationic lipid composition and/or liposomes having a cholesterol backbone conjugated to polyethylene glycol. Optionally, a liposome comprises a compound capable of targeting the liposome to a particular cell type, such as a cell-specific ligand exposed on the outer surface of the liposome.

Complexing a liposome with a reagent such as an antisense oligonucleotide or ribozyme can be achieved using methods that are standard in the art (see, for example, U.S. Patent 5,705,151). Preferably, from about 0.1 μg to about 10 μg of

polynucleotide is combined with about 8 nmol of liposomes, more preferably from about 0.5 μg to about 5 μg of polynucleotides are combined with about 8 nmol liposomes, and even more preferably about 1.0 μg of polynucleotides is combined with about 8 nmol liposomes.

In another embodiment, antibodies can be delivered to specific tissues *in vivo* using receptor-mediated targeted delivery. Receptor-mediated DNA delivery techniques are taught in, for example, Findeis *et al. Trends in Biotechnol. 11*, 202-05 (1993); Chiou *et al.*, GENE THERAPEUTICS: METHODS AND APPLICATIONS OF DIRECT GENE TRANSFER (J.A. Wolff, ed.) (1994); Wu & Wu, *J. Biol. Chem. 263*, 621-24 (1988); Wu *et al.*, *J. Biol. Chem. 269*, 542-46 (1994); Zenke *et al.*, *Proc. Natl. Acad. Sci. U.S.A. 87*, 3655-59 (1990); Wu *et al.*, *J. Biol. Chem. 266*, 338-42 (1991).

Determination of a Therapeutically Effective Dose

The determination of a therapeutically effective dose is well within the capability of those skilled in the art. A therapeutically effective dose refers to that amount of active ingredient which increases or decreases transient receptor potential channel activity relative to the transient receptor potential channel activity which occurs in the absence of the therapeutically effective dose.

For any compound, the therapeutically effective dose can be estimated initially either in cell culture assays or in animal models, usually mice, rabbits, dogs, or pigs. The animal model also can be used to determine the appropriate concentration range and route of administration. Such information can then be used to determine useful doses and routes for administration in humans.

Therapeutic efficacy and toxicity, *e.g.*, ED_{50} (the dose therapeutically effective in 50% of the population) and LD_{50} (the dose lethal to 50% of the population), can be determined by standard pharmaceutical procedures in cell cultures or experimental

animals. The dose ratio of toxic to therapeutic effects is the therapeutic index, and it can be expressed as the ratio, LD_{50}/ED_{50}.

Pharmaceutical compositions that exhibit large therapeutic indices are preferred. The data obtained from cell culture assays and animal studies is used in formulating a range of dosage for human use. The dosage contained in such compositions is preferably within a range of circulating concentrations that include the ED_{50} with little or no toxicity. The dosage varies within this range depending upon the dosage form employed, sensitivity of the patient, and the route of administration.

The exact dosage will be determined by the practitioner, in light of factors related to the subject that requires treatment. Dosage and administration are adjusted to provide sufficient levels of the active ingredient or to maintain the desired effect. Factors that can be taken into account include the severity of the disease state, general health of the subject, age, weight, and gender of the subject, diet, time and frequency of administration, drug combination(s), reaction sensitivities, and tolerance/response to therapy. Long-acting pharmaceutical compositions can be administered every 3 to 4 days, every week, or once every two weeks depending on the half-life and clearance rate of the particular formulation.

Normal dosage amounts can vary from 0.1 to 100,000 micrograms, up to a total dose of about 1 g, depending upon the route of administration. Guidance as to particular dosages and methods of delivery is provided in the literature and generally available to practitioners in the art. Those skilled in the art will employ different formulations for nucleotides than for proteins or their inhibitors. Similarly, delivery of polynucleotides or polypeptides will be specific to particular cells, conditions, locations, etc.

If the reagent is a single-chain antibody, polynucleotides encoding the antibody can be constructed and introduced into a cell either *ex vivo* or *in vivo* using well-established techniques including, but not limited to, transferrin-polycation-mediated

DNA transfer, transfection with naked or encapsulated nucleic acids, liposome-mediated cellular fusion, intracellular transportation of DNA-coated latex beads, protoplast fusion, viral infection, electroporation, "gene gun," and DEAE- or calcium phosphate-mediated transfection.

Effective *in vivo* dosages of an antibody are in the range of about 5 μg to about 50 μg/kg, about 50 μg to about 5 mg/kg, about 100 μg to about 500 μg/kg of patient body weight, and about 200 to about 250 μg/kg of patient body weight. For administration of polynucleotides encoding single-chain antibodies, effective *in vivo* dosages are in the range of about 100 ng to about 200 ng, 500 ng to about 50 mg, about 1 μg to about 2 mg, about 5 μg to about 500 μg, and about 20 μg to about 100 μg of DNA.

If the expression product is mRNA, the reagent is preferably an antisense oligonucleotide or a ribozyme. Polynucleotides that express antisense oligonucleotides or ribozymes can be introduced into cells by a variety of methods, as described above.

Preferably, a reagent reduces expression of a transient receptor potential channel gene or the activity of a transient receptor potential channel polypeptide by at least about 10, preferably about 50, more preferably about 75, 90, or 100% relative to the absence of the reagent. The effectiveness of the mechanism chosen to decrease the level of expression of a transient receptor potential channel gene or the activity of a transient receptor potential channel polypeptide can be assessed using methods well known in the art, such as hybridization of nucleotide probes to transient receptor potential channel-specific mRNA, quantitative RT-PCR, immunologic detection of a transient receptor potential channel polypeptide, or measurement of transient receptor potential channel activity.

In any of the embodiments described above, any of the pharmaceutical compositions of the invention can be administered in combination with other appropriate therapeutic agents. Selection of the appropriate agents for use in combination therapy can

be made by one of ordinary skill in the art, according to conventional pharmaceutical principles. The combination of therapeutic agents can act synergistically to effect the treatment or prevention of the various disorders described above. Using this approach, one may be able to achieve therapeutic efficacy with lower dosages of each agent, thus reducing the potential for adverse side effects.

Any of the therapeutic methods described above can be applied to any subject in need of such therapy, including, for example, mammals such as dogs, cats, cows, horses, rabbits, monkeys, and most preferably, humans.

Diagnostic Methods

Human transient receptor potential channel also can be used in diagnostic assays for detecting diseases and abnormalities or susceptibility to diseases and abnormalities related to the presence of mutations in the nucleic acid sequences that encode the polypeptide. For example, differences can be determined between the cDNA or genomic sequence encoding transient receptor potential channel in individuals afflicted with a disease and in normal individuals. If a mutation is observed in some or all of the afflicted individuals but not in normal individuals, then the mutation is likely to be the causative agent of the disease.

Sequence differences between a reference gene and a gene having mutations can be revealed by the direct DNA sequencing method. In addition, cloned DNA segments can be employed as probes to detect specific DNA segments. The sensitivity of this method is greatly enhanced when combined with PCR. For example, a sequencing primer can be used with a double-stranded PCR product or a single-stranded template molecule generated by a modified PCR. The sequence determination is performed by conventional procedures using radiolabeled nucleotides or by automatic sequencing procedures using fluorescent tags.

Genetic testing based on DNA sequence differences can be carried out by detection of alteration in electrophoretic mobility of DNA fragments in gels with or without denaturing agents. Small sequence deletions and insertions can be visualized, for example, by high resolution gel electrophoresis. DNA fragments of different sequences can be distinguished on denaturing formamide gradient gels in which the mobilities of different DNA fragments are retarded in the gel at different positions according to their specific melting or partial melting temperatures (*see, e.g.*, Myers *et al.*, *Science 230*, 1242, 1985). Sequence changes at specific locations can also be revealed by nuclease protection assays, such as RNase and S 1 protection or the chemical cleavage method (*e.g.*, Cotton *et al.*, *Proc. Natl. Acad. Sci. USA 85*, 4397-4401, 1985). Thus, the detection of a specific DNA sequence can be performed by methods such as hybridization, RNase protection, chemical cleavage, direct DNA sequencing or the use of restriction enzymes and Southern blotting of genomic DNA. In addition to direct methods such as gel-electrophoresis and DNA sequencing, mutations can also be detected by *in situ* analysis.

Altered levels of transient receptor potential channel also can be detected in various tissues. Assays used to detect levels of the receptor polypeptides in a body sample, such as blood or a tissue biopsy, derived from a host are well known to those of skill in the art and include radioimmunoassays, competitive binding assays, Western blot analysis, and ELISA assays.

All patents and patent applications cited in this disclosure are expressly incorporated herein by reference. The above disclosure generally describes the present invention. A more complete understanding can be obtained by reference to the following specific examples, which are provided for purposes of illustration only and are not intended to limit the scope of the invention.

EXAMPLE 1

Expression of recombinant human transient receptor potential channel

The *Pichia pastoris* expression vector pPICZB (Invitrogen, San Diego, CA) is used to produce large quantities of recombinant human transient receptor potential channel polypeptides in yeast. The transient receptor potential channel-encoding DNA sequence is derived from any one of SEQ ID NOs: 1 to 11. Before insertion into vector pPICZB, the DNA sequence is modified by well known methods in such a way that it contains at its 5'-end an initiation codon and at its 3'-end an enterokinase cleavage site, a His6 reporter tag and a termination codon. Moreover, at both termini recognition sequences for restriction endonucleases are added and after digestion of the multiple cloning site of pPICZ B with the corresponding restriction enzymes the modified DNA sequence is ligated into pPICZB. This expression vector is designed for inducible expression in *Pichia pastoris*, driven by a yeast promoter. The resulting pPICZ/md-His6 vector is used to transform the yeast.

The yeast is cultivated under usual conditions in 5 liter shake flasks and the recombinantly produced protein isolated from the culture by affinity chromatography (Ni-NTA-Resin) in the presence of 8 M urea. The bound polypeptide is eluted with buffer, pH 3.5, and neutralized. Separation of the polypeptide from the His6 reporter tag is accomplished by site-specific proteolysis using enterokinase (Invitrogen, San Diego, CA) according to manufacturer's instructions. Purified human transient receptor potential channel polypeptide is obtained.

EXAMPLE 2

Identification of test compounds that bind to transient receptor potential channel polypeptides

Purified transient receptor potential channel polypeptides comprising a glutathione-S-transferase protein and absorbed onto glutathione-derivatized wells of 96-well microtiter plates are contacted with test compounds from a small molecule library at

pH 7.0 in a physiological buffer solution. Human transient receptor potential channel polypeptides comprise the amino acid sequence any one of sequences shown in SEQ ID NOS: 12 to 21. The test compounds comprise a fluorescent tag. The samples are incubated for 5 minutes to one hour. Control samples are incubated in the absence of a test compound.

The buffer solution containing the test compounds is washed from the wells. Binding of a test compound to a transient receptor potential channel polypeptide is detected by fluorescence measurements of the contents of the wells. A test compound that increases the fluorescence in a well by at least 15% relative to fluorescence of a well in which a test compound is not incubated is identified as a compound which binds to a transient receptor potential channel polypeptide.

EXAMPLE 3

Identification of a test compound which decreases transient receptor potential channel gene expression

A test compound is administered to a culture of human cells transfected with a transient receptor potential channel expression construct and incubated at 37°C for 10 to 45 minutes. A culture of the same type of cells that have not been transfected is incubated for the same time without the test compound to provide a negative control.

RNA is isolated from the two cultures as described in Chirgwin *et al.*, *Biochem. 18*, 5294-99, 1979). Northern blots are prepared using 20 to 30 µg total RNA and hybridized with a ^{32}P-labeled transient receptor potential channel-specific probe at 65 ° C in Express-hyb (CLONTECH). The probe comprises at least 11 contiguous nucleotides selected from the complement of SEQ ID NOs 1 to 11. A test compound that decreases the transient receptor potential channel-specific signal relative to the signal obtained in the absence of the test compound is identified as an inhibitor of transient receptor potential channel gene expression.

EXAMPLE 4

Tissue-specific expression of transient receptor potential channel

The qualitative expression pattern of transient receptor potential channel in various tissues is determined by Reverse Transcription-Polymerase Chain Reaction (RT-PCR).

To demonstrate that transient receptor potential channel is involved in CNS disorders, the following tissues are screened: fetal and adult brain, muscle, heart, lung, kidney, liver, thymus, testis, colon, placenta, trachea, pancreas, kidney, gastric mucosa, colon, liver, cerebellum, skin, cortex (Alzheimer's and normal), hypothalamus, cortex, amygdala, cerebellum, hippocampus, choroid, plexus, thalamus, and spinal cord.

Quantitative expression profiling. Quantitative expression profiling is performed by the form of quantitative PCR analysis called "kinetic analysis" firstly described in Higuchi *et al.*, *BioTechnology 10*, 413-17, 1992, and Higuchi *et al.*, *BioTechnology 11*, 1026-30, 1993. The principle is that at any given cycle within the exponential phase of PCR, the amount of product is proportional to the initial number of template copies.

If the amplification is performed in the presence of an internally quenched fluorescent oligonucleotide (TaqMan probe) complementary to the target sequence, the probe is cleaved by the 5'-3' endonuclease activity of Taq DNA polymerase and a fluorescent dye released in the medium (Holland *et al.*, *Proc. Natl. Acad. Sci. U.S.A. 88*, 7276-80, 1991). Because the fluorescence emission will increase in direct proportion to the amount of the specific amplified product, the exponential growth phase of PCR product can be detected and used to determine the initial template concentration (Heid *et al.*, *Genome Res. 6*, 986-94, 1996, and Gibson *et al.*, *Genome Res. 6*, 995-1001, 1996).

The amplification of an endogenous control can be performed to standardize the amount of sample RNA added to a reaction. In this kind of experiment, the control of choice is the 18S ribosomal RNA. Because reporter dyes with differing emission spectra are available, the target and the endogenous control can be independently quantified in the same tube if probes labeled with different dyes are used.

All "real time PCR" measurements of fluorescence are made in the ABI Prism 7700.

RNA extraction and cDNA preparation. Total RNA from the tissues listed above are used for expression quantification. RNAs labeled "from autopsy" were extracted from autoptic tissues with the TRIzol reagent (Life Technologies, MD) according to the manufacturer's protocol.

Fifty µg of each RNA were treated with DNase I for 1 hour at 37°C in the following reaction mix: 0.2 U/µl RNase-free DNase I (Roche Diagnostics, Germany); 0.4 U/µl RNase inhibitor (PE Applied Biosystems, CA); 10 mM Tris-HCl pH 7.9; 10mM $MgCl_2$; 50 mM NaCl; and 1 mM DTT.

After incubation, RNA is extracted once with 1 volume of phenol:chloroform:iso-amyl alcohol (24:24:1) and once with chloroform, and precipitated with 1/10 volume of 3 M NaAcetate, pH5.2, and 2 volumes of ethanol.

Fifty µg of each RNA from the autoptic tissues are DNase treated with the DNA-free kit purchased from Ambion (Ambion, TX). After resuspension and spectrophotometric quantification, each sample is reverse transcribed with the TaqMan Reverse Transcription Reagents (PE Applied Biosystems, CA) according to the manufacturer's protocol. The final concentration of RNA in the reaction mix is 200ng/µL. Reverse transcription is carried out with 2.5µM of random hexamer primers.

TaqMan quantitative analysis. Specific primers and probe are designed according to the recommendations of PE Applied Biosystems; the probe can be labeled at the 5' end FAM (6-carboxy-fluorescein) and at the 3' end with TAMRA (6-carboxy-tetra-methyl-rhodamine). Quantification experiments are performed on 10 ng of reverse transcribed RNA from each sample. Each determination is done in triplicate.

Total cDNA content is normalized with the simultaneous quantification (multiplex PCR) of the 18S ribosomal RNA using the Pre-Developed TaqMan Assay Reagents (PDAR) Control Kit (PE Applied Biosystems, CA).

The assay reaction mix is as follows: 1X final TaqMan Universal PCR Master Mix (from 2X stock) (PE Applied Biosystems, CA); 1X PDAR control – 18S RNA (from 20X stock); 300 nM forward primer; 900 nM reverse primer; 200 nM probe; 10 ng cDNA; and water to 25 µl.

Each of the following steps are carried out once: pre PCR, 2 minutes at 50°C, and 10 minutes at 95°C. The following steps are carried out 40 times: denaturation, 15 seconds at 95°C, annealing/extension, 1 minute at 60°C.

The experiment is performed on an ABI Prism 7700 Sequence Detector (PE Applied Biosystems, CA). At the end of the run, fluorescence data acquired during PCR are processed as described in the ABI Prism 7700 user's manual in order to achieve better background subtraction as well as signal linearity with the starting target quantity.

EXAMPLE 5

Trp-p8/CMR1 agonists or antagonists are going to be studied using genomically produced cell lines expressing Trp-p8 in mammalian stable cell lines such as CHO and HEK host cells. In addition to recombinant cells DRG neuron cells isolated from experimental animals can be used for the characterization of the modulators. New

born Wister rats (5-11 days) are sacrificed and DRG is removed. DRG is incubated with 0.1% trypsin in PBS for 30 min at 37°C, then a half volume of fetal calf serum (FCS) is added and the cells are spun down. The DRG neuron cells are resuspended in Ham F12/10% FCS and dispersed by repeated pipetting and passing through 70 µm mesh. The culture plate is incubated for 3 hours at 37°C to remove contaminating Schwann cells. Non-adherent cells are recovered and further cultured in laminin-coated 384 well plates at $1x10^4$ cells/50 µl/well for 2 days in the presence of 50 ng/ml recombinant rat NGF and 50 µM 5-fluorodeoxyuridine. DRG neuron cells are washed twice with HBSS supplemented with 17 mM HEPES (pH 7.4) and 0.1% BSA. After incubating with 2 µM fluo-3AM, 0.02% PF127 and 1 mM probenecid for 40 min at 37°C, cells are washed 3 times. The cells are incubated with antagonists or vehicle (dimethylsulphoxide) and then with 1 µM agonist such as menthol or icilin in FDSS-6000 (λ_{ex}=480nm, λ_{em}=520nm / Hamamatsu Photonics). The fluorescence changes at 480nm are monitored for 2.5 min. Integral R is calculated and compared with controls.

EXAMPLE 6

Effects of candidate drugs on the contractility of the bladder detrusor are estimated by organ bath assay. Organ bath assay to measure the agonist-induced contraction of bladder is employed for assessing the biological activity of drug candidates. Male Wistar rats (10 week old) are anesthetized with ether and sacrificed by dislocating the necks. The whole urinary bladder is excised and placed in oxygenated Modified Krebs-Henseleit solution (pH 7.4) of the following composition (112mM NaCl, 5.9mM KCl, 1.2mM $MgCl_2$, 1.2mM NaH_2PO_4, 2mM $CaCl_2$, 2.5mM $NaHCO_3$, 12mM glucose). Isometric tension is recorded under an appropriate load using longitudinal strips of rat detrusor muscle. Bladder strips are equilibrated for 60 min before each stimulation. Contractile response to 80 mM KCl is determined at 15 min intervals until reproducible responses are obtained. The response to KCl is used as an internal standard to evaluate the effect of test compounds. The effects of the compounds are investigated by incubating the strips with compounds for 30 min prior to

the stimulation with an appropriate agonist or electrical stimulation. One of the preparations made from the same animal is served as a control while the others are used for evaluating compounds. Ratio of each contraction to the internal standard (i.e. KCl-induced contraction) is calculated and the effects of the test compounds on the contraction are evaluated.

EXAMPLE 7

Organ bath assay is used for estimating the biological activity of drug candidates on the prostate contractility. Organ bath assay to measure the agonist-induced contraction of bladder is employed for assessing the biological activity of drug candidates. A male New Zealand white rabbit is intravenously injected with overdose of Nembutal to sacrifice. The whole prostate is excised and placed in oxygenated Modified Krebs-Henseleit solution (pH 7.4) of the following composition (112mM NaCl, 5.9mM KCl, 1.2mM $MgCl_2$, 1.2mM NaH_2PO_4, 2mM $CaCl_2$, 2.5mM $NaHCO_3$, 12mM glucose). Isometric tension is recorded under an appropriate load using strips of rabbit prostate. Prostate strips are equilibrated for 60 min before each stimulation. Contractile response to 1μM phenylephrine, 80 mM KCl or electric field stimulation is determined at appropriate intervals until reproducible responses are obtained. The response to the selected stimulant is used as an internal standard to evaluate the effect of test compounds. The effects of the compounds are investigated by incubating the strips with compounds for 30 min prior to the stimulation with an appropriate agonist or electrical stimulation. One of the preparations made from the same animal is served as a control while the others are used for evaluating compounds. Ratio of each contraction to the internal standard (i.e. stimulant-induced contraction) is calculated and the effects of the test compounds on the contraction are evaluated.

EXAMPLE 8

Micturition parameters from cystometry are utilized to evaluate the drug candidates for micturition disorders. Sprague-Dawley rats are anesthetized by intraperitoneal administration of urethane at 1.2g/kg. The abdomen is opened through a midline incision, and a polyethylene catheter is implanted into the bladder through the dome. In parallel, the inguinal region is incised, and a polyethylene catheter filled with 2 IU/ml of heparin in saline is inserted into a common iliac artery. The bladder catheter is connected via T-tube to a pressure transducer and a microinjection pump. Saline is infused at room temperature into the bladder at a rate of 2.4 ml/hr. Intravesical pressure is recorded continuously on a chart pen recorder. At least three reproducible micturition cycles are recorded before a test compound administration and used as baseline values. The saline infusion is stopped before administrating compounds. A testing compound dissolved in an appropriate vehicle is intraarterialy injected 2min before another intraarterial administration of stimulant such as menthol or icilin. Relative increases in the induced intravesical pressure are analyzed from the cystometry data in comparison with the normal micturition patterns. The testing compounds–mediated inhibition of the increased bladder pressures is evaluated using Student's t-test. A probability level less than 5% is accepted as significant difference.

EXAMPLE 9

For the assessment of the drugs affecting on LUTS following the Bladder Outlet Obstruction model is useful. To obtain a partial obstruction of the urethra, Wistar rats are anesthetized with ketamine, intraperitoneally. The abdomen is opened through a midline incision and the bladder and the proximal urethra are exposed. A constant degree of urethral obstruction is produced by tying a ligature around the urethra and a catheter with an outer diameter of 1 mm. The abdominal well is closed and the animals allowed to recover. After 6 weeks, the rats are anesthetized with ketamine and the ligature around the urethra was carefully removed, to normalize the

outlet resistance and enable repetitive micturition. A polyethylene catheter is implanted in the bladder through the dome, and exteriorized at the scapular level. Animals are then allowed to recover for at least 48 hours. Cytometric investigation is performed without anesthesia two days after bladder catheter implantation in control and obstructed animals. The bladder catheter was connected via a T-tube to a strain gauge and a microinjection pump. The conscious rats were held under partial restraint in a restraining device. Warmed saline was infused into the bladder at a rate of 3 ml/hr for control and obstructed animals. The rate of infusion was increased from 3 to 10 ml/hr to obtain similar interval times between micturitions in obstructed and control rats. Overactivity of the obstructed bladders is assessed by measuring the cystometric parameters such as basal pressure, peak micturition pressure, threshold pressure, micturition interval, amplitude and frequency of spontaneous activity and micturition slope. [Lluel P, Duquenne C, Martin D; Experimental bladder instability following bladder outlet obstruction in the female rat. J. Urol. 160:2253-2257, 1998].

REFERENCES

1. From worm to man: three subfamilies of TRP channels. Harteneck C, Plant TD, Schultz G, Trends Neurosci 2000 Apr;23(4):159-66.

2. Cloning, expression and subcellular localization of two novel splice variants of mouse transient receptor potential channel 2, Hofmann T, Schaefer M, Schultz G, Gudermann T, Biochem. J. 2000 Oct1;351(Pt 1):115-122.

3. Cloning and expression of the human transient receptor potential 4 (TRP4) gene: localization and functional expression of human TRP4 and TRP3. McKay RR, Szymeczek-Seay CL, Lievremont JP, Bird GS, Zitt C, Jungling E, Luckhoff A, Putney Jr JW, Biochem J 2000 Nov 1;351 Pt 3:735-46.

4. Cloning and expression of the human transient receptor potential 4 (TRP4) gene: Mucolipidosis type IV is caused by mutations in a gene encoding a novel transient receptor potential channel. Sun M, Goldin E, Stahl S, Falardeau JL, Kennedy JC, Acierno JS Jr, Bove C, Kaneski CR, Nagle J, Bromley MC, Colman M, Schiffmann R, Slaugenhaupt SA, Hum Mol Genet 2000 Oct 12;9(17):2471-8.

5. Direct activation of human TRPC6 and TRPC3 channels by diacylglycerol. Hofmann T, Obukhov AG, Schaefer M, Harteneck C, Gudermann T, Schultz G, Nature 1999 Jan 21;397(6716):259-63.

6. Identification and characterization of MTR1, a novel gene with homology to melastatin (MLSN1) and the trp gene family located in the BWS-WT2 critical region on chromosome 11p15.5 and showing allele-specific expression. Prawitt D, Enklaar T, Klemm G, Gartner B, Spangenberg C, Winterpacht A, Higgins M, Pelletier J, Zabel B, Hum Mol Genet 2000 Jan 22;9(2):203-16.

7. Evidence for a role of Trp proteins in the oxidative stress-induced membrane conductances of porcine aortic endothelial cells. Balzer M, Lintschinger B, Groschner K, Cardiovasc Res 1999 May;42(2):543-9.

8. Receptor-mediated regulation of the nonselective cation channels TRPC4 and TRPC5. Schaefer M, Plant TD, Obukhov AG, Hofmann T, Gudermann T, Schultz G, : J Biol Chem 2000 Jun 9;275(23):17517-26.

CLAIMS

1. A method of screening for agents which decrease the activity of human transient receptor channel, comprising the steps of:

i) contacting a test compound with any human transient receptor channel polypeptide encoded by any polynucleotide being selected from the group consisting of:

a) a polynucleotide encoding a human transient receptor channel polypeptide comprising an amino acid sequence selected from the group constisting of:

amino acid sequences which are at least about 50% identical to any one of the amino acid sequences shown in SEQ ID NO:12 to 21; and

any one of the amino acid sequences shown in SEQ ID NO:12 to 21;

b) a polynucleotide comprising any one of the sequences of SEQ ID NOS:1 to 11;

c) a polynucleotide which hybridizes under stringent conditions to a polynucleotide specified in (a) and (b) and encodes a human transient receptor channel;

d) a polynucleotide the nucleic acid sequence of which deviates from the nucleic acid sequences specified in (a) to (c) due to the degeneration of the genetic code and encodes a human transient receptor channel; and

e) a polynucleotide, which represents a fragment, derivative or allelic variation of a nucleic acid sequence specified in (a) to (d) and encodes a human transient receptor channel;

ii) detecting binding of the test compound to the human transient receptor channel polypeptide,

wherein a test compound which binds to the polypeptide is identified as a potential therapeutic agent for decreasing the activity of a human transient receptor channel and for treating urological disorders.

2. A method of screening for agents which regulate the activity of a human transient receptor channel, comprising the steps of:

i) contacting a test compound with a human transient receptor channel polypeptide encoded by any of the polynucleotides polynucleotide being selected from the group consisting of:

a) a polynucleotide encoding a human transient receptor channel polypeptide comprising an amino acid sequence selected from the group constisting of:

amino acid sequences which are at least about 50% identical to any one of the amino acid sequences shown in SEQ ID NO:12 to 21; and

any one of the amino acid sequences shown in SEQ ID NO:12 to 21;

b) a polynucleotide comprising the sequence of SEQ ID NOS:1 to 11;

c) a polynucleotide which hybridizes under stringent conditions to a polynucleotide specified in (a) and (b) and encodes a human transient receptor channel;

d) a polynucleotide the nucleic acid sequence of which deviates from the nucleic acid sequences specified in (a) to (c) due to the degeneration of the genetic code and encodes a human transient receptor channel; and

e) a polynucleotide, which represents a fragment, derivative or allelic variation of a nucleic acid sequence specified in (a) to (d) and encodes a human transient receptor channel; and

ii) detecting a human transient receptor channel activity of the polypeptide,

wherein a test compound which increases the human transient receptor channel activity is identified as a potential therapeutic agent for increasing the activity of the human transient receptor channel and useful to treat urological disorders, and wherein a test compound which decreases the human transient receptor channel activity of the polypeptide is identified as a potential therapeutic agent for decreasing the activity of the human transient receptor channel and useful to treat urological disorders.

3. A method of screening for agents which decrease the activity of a human transient receptor channel, comprising the steps of:

i) contacting a test compound with any polynucleotide polynucleotide being selected from the group consisting of:

a) a polynucleotide encoding a human transient receptor channel polypeptide comprising an amino acid sequence selected from the group constisting of:

amino acid sequences which are at least about 50% identical to any one of the amino acid sequences shown in SEQ ID NO:12 to 21; andny one of the amino acid sequences shown in SEQ ID NO:12 to 21;

b) a polynucleotide comprising the sequence of SEQ ID NOS:1 to 11;

c) a polynucleotide which hybridizes under stringent conditions to a polynucleotide specified in (a) and (b) and encodes a human transient receptor channel;

d) a polynucleotide the nucleic acid sequence of which deviates from the nucleic acid sequences specified in (a) to (c) due to the degeneration of the genetic code and encodes a human transient receptor channel; and

e) a polynucleotide, which represents a fragment, derivative or allelic variation of a nucleic acid sequence specified in (a) to (d) and encodes a human transient receptor channel; and

ii) detecting binding of the test compound to the polynucleotide,

wherein a test compound which binds to the polynucleotide is identified as a potential therapeutic agent for decreasing the activity of the human transient receptor channel and useful to treat urological disorders.

4. A method of reducing the activity of human transient receptor channel, comprising the step of:

contacting a cell with a reagent which specifically binds to any polynucleotide being selected from the group consisting of:

a) a polynucleotide encoding a human transient receptor channel polypeptide comprising an amino acid sequence selected from the group constisting of:

amino acid sequences which are at least about 50% identical to any one of the amino acid sequences shown in SEQ ID NO:12 to 21; and

any one of the amino acid sequences shown in SEQ ID NO:12 to 21;

b) a polynucleotide comprising the sequence of SEQ ID NOS:1 to 11;

c) a polynucleotide which hybridizes under stringent conditions to a polynucleotide specified in (a) and (b) and encodes a human transient receptor channel;

d) a polynucleotide the nucleic acid sequence of which deviates from the nucleic acid sequences specified in (a) to (c) due to the degeneration of the genetic code and encodes a human transient receptor channel; and

e) a polynucleotide, which represents a fragment, derivative or allelic variation of a nucleic acid sequence specified in (a) to (d) and encodes a human transient receptor channel

or a human transient receptor channel polypeptide encoded by the any one of the polynucleotides (a) to (e), whereby the activity of human transient receptor channel is reduced.

5. A reagent that modulates the activity of a human transient receptor channel polypeptide or polynucleotide, wherein said reagent is identified by the method of any of the claims 1 to 4 and useful to treat urological disorders.

6. A pharmaceutical composition for the treatment of urological disorders, comprising:
the reagent of claim 5, and
a pharmaceutically acceptable carrier.

7. Use of the reagent of claim 5 in the preparation of a medicament for modulating the activity of human transient receptor channel in a urological disorder.

8. Use of claim 7, wherein the urological disorder is at least one selected from the group consisting of a disorder caused by overactivity of bladder, hyperflexia, benign prostatic hyperplasia, and one of lower urinary tract syndromes.